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Journal of Applied Psychology

EDITED BY: DONALD G. PATERSON, UNIVERSITY OF MINNESOTA

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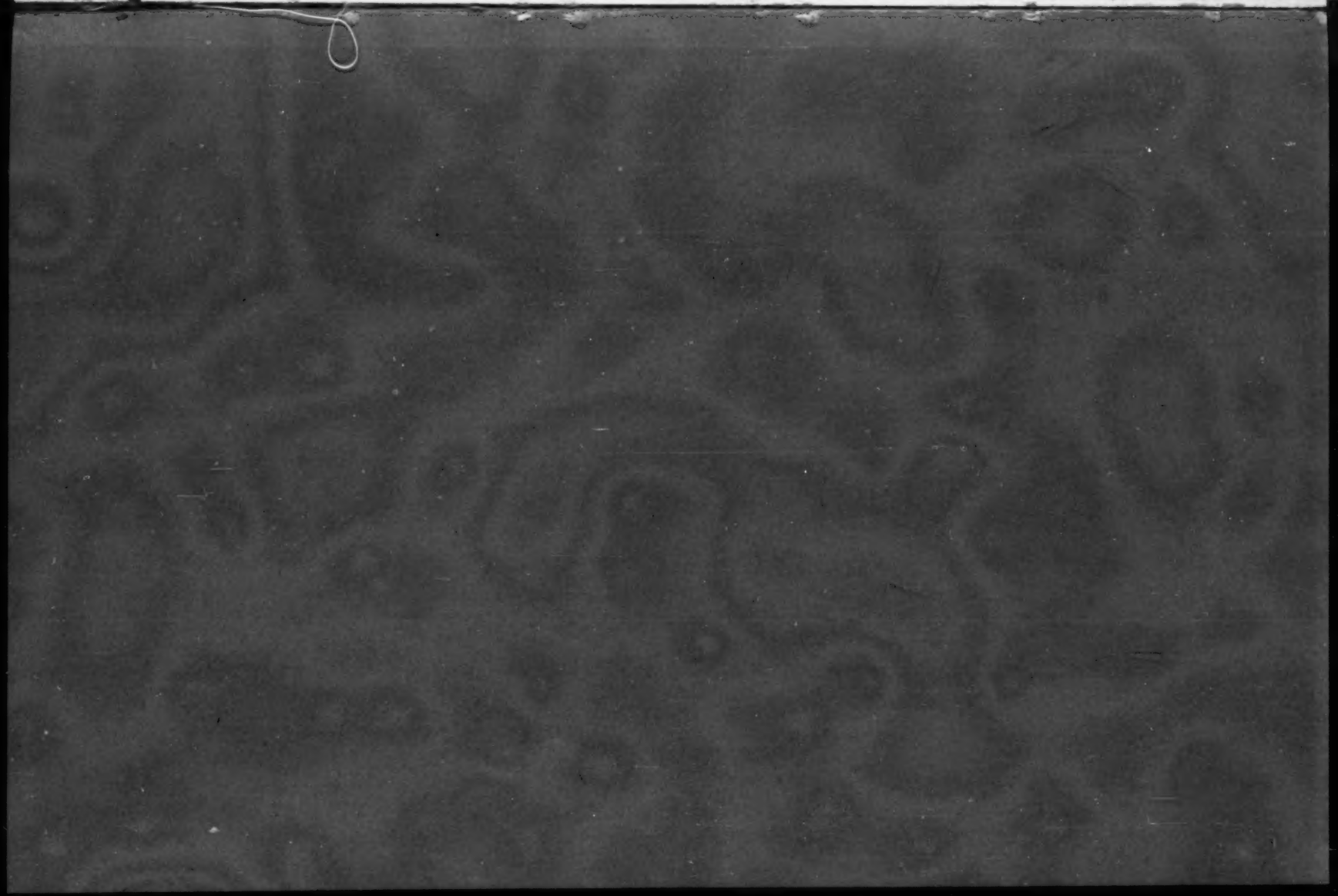

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Journal of Applied Psychology

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The Accuracy of Precision Instrument Measurement in Industrial Inspection *

C. H. Lawshe, Jr., and Joseph Tiffin

Division of Education and Applied Psychology, Purdue University

Modern industrial production is becoming more and more dependent upon the accuracy of precision instrument inspection. Thousands of employees have been trained in the use of precision measuring instruments, and future industrial developments almost certainly will require still greater emphasis on the accuracy of measurement to insure production which satisfies the fine tolerances of modern precision equipment. Virtually every precision instrument calls upon the operator to exercise judgment in determining proper "feel," "tension," "drag," or other characteristics. In spite of all that is known about the variability of human judgments, little attention has been given to the importance of such variability as it may affect the accuracy of precision instrument measurement. The purpose of the investigation reported in the present paper was to examine the accuracy and variability of employee measurements with certain precision instruments.

Sources of Data. Data were collected in two different plants. The first of these is engaged in the manufacture of variable pitch propellers for aircraft and the second in the manufacture of precision parts for aircraft and automobile engines. There is no evidence that the survey results obtained are any better or any worse than those which would be obtained in other plants of a similar character and there is every reason to believe that similar results would be obtained if the survey were projected to other plants.

An Inspection Department Survey

Job Analysis. Approximately 200 people are employed in the inspection department of the first plant. Their jobs were analyzed by job

* The authors acknowledge the assistance of Mr. O. D. Lascoe in establishing the "true" dimensions and of Mr. R. N. Purcell in doing most of the statistical work in connection with the second part of the study.

classifications in order to determine what precision instruments are used and what tolerances are demanded on each job. Frequency counts were then made to determine which instruments or combinations of instruments are used in the largest number of classifications and by the largest number of employees. On the basis of this count, twenty instruments and combinations were chosen as being most important in this particular plant.

A Dimensional Control Laboratory. A room was set aside as a dimensional control laboratory and twenty booths or inspection stations were set up. Each booth was numbered and in it were placed one of the twenty instruments, a standard part from the plant, and a simplified working drawing which indicated one dimension to be measured with the instrument provided. When an employee entered the room, the attendant determined his job classification and provided him with an appropriate work-sheet for each of the stations containing work samples from his job. Each employee was tested on only those instruments which he uses on his particular job. He was encouraged to make five measurements and then to record his best judgment as to the dimension. The readings thus obtained were compared with so-called "true" dimensions which were determined by means of ultra-precision instruments in combination with Johansen blocks. Instruments utilized in the performance testing were checked and adjusted periodically to insure constancy.

Emphasis of Testing. This performance testing procedure was organized in connection with a training program and its primary function was to identify persons in need of training. Plans for a maintenance program were also made with provisions for re-testing employees every three months. It was also planned to utilize the laboratory to supplement seniority in determining adequacy in connection with transfers and promotions. The program was instituted with the knowledge and backing of line supervision and of the union in the plant. There is every reason to believe that nearly all of the employees approaches the test situation with a favorable attitude.

Results

Results obtained at eleven of the twenty stations are presented in Figure 1. The particular stations selected for illustration were chosen in terms of general familiarity with the instruments used and not because of any peculiarity in the findings; they are truly representative.

In Figure 1, the open bars represent the percentage of inspectors tested who obtained readings within the established tolerance. The solid bars represent the percentage of persons tested who failed to meet the standard. As already stated, not all of the inspectors were tested at each station; instead, the sample contains only those who use the instruments

on their jobs. This accounts for the fact that the N's range from 117 to 162. The figure indicates that the percentage of inspectors meeting the various standards ranged from a high of 66% on the inside microm-

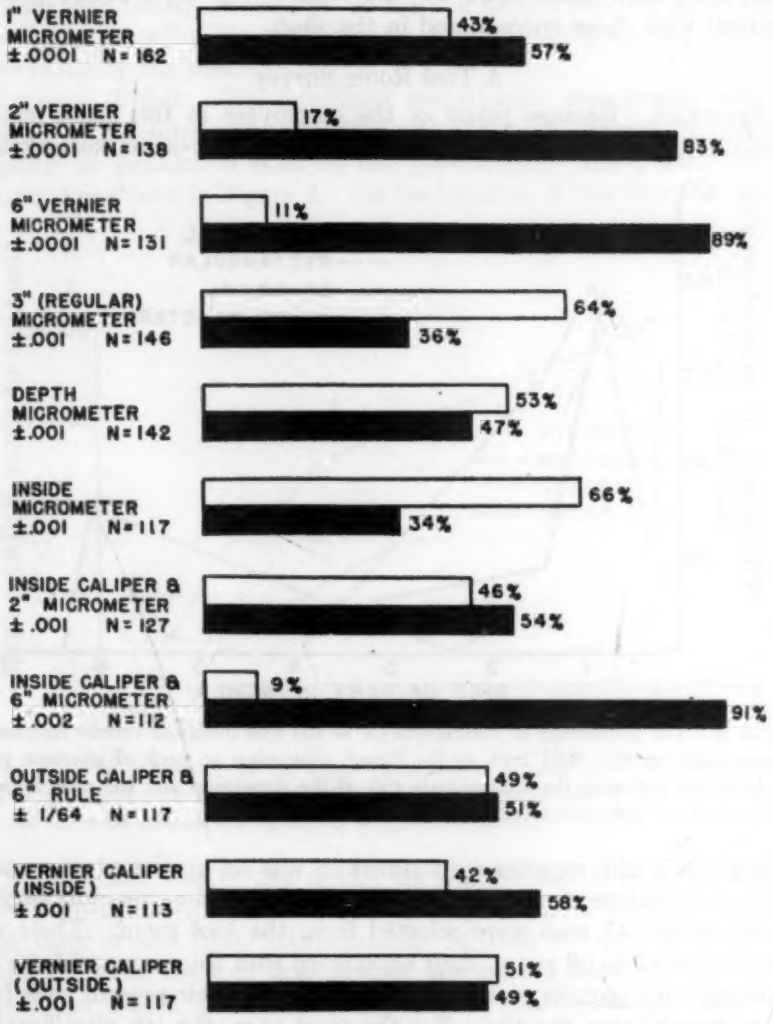

FIG. 1. The percentage of inspectors passing and failing various precision measuring instrument performance tests in an aircraft propeller plant. The open bars indicate the percentage meeting the standard and the solid bars indicate the percentage failing.

eter to a low of 9% on the inside caliper in combination with the six-inch micrometer. The pattern of performance on the various vernier micrometers also seems significant. It will be noted that 43% of those tested

met the standard with the one-inch micrometer, 17% with the two-inch, and only 11% with the six-inch. The varying tolerances established for the instruments are the same as the tolerances which job analyses indicated had been established by the engineering department and are identical with those encountered in the shop.

A Tool Room Survey

Procedure. Because many of the employees in the plant just described were new and were drawn from a "tight" labor market, a related

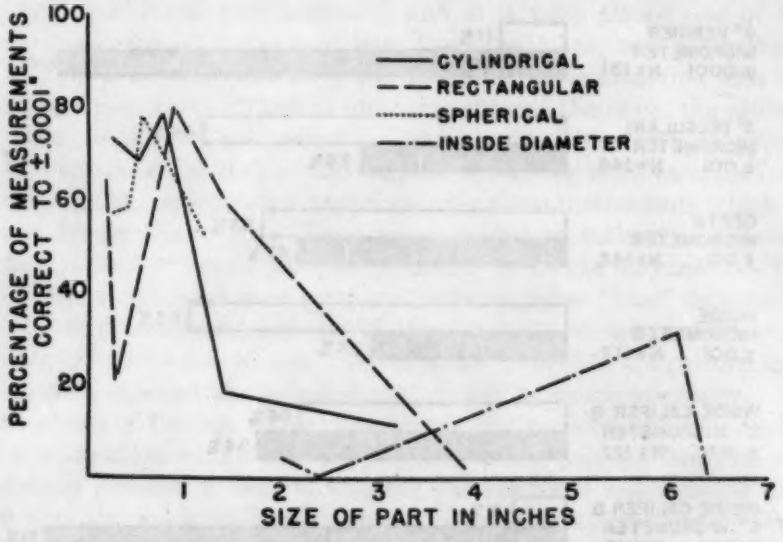

FIG. 2. The percentage of toolmakers ($N = 45$) who obtained vernier micrometer measurements within .0001 inch of the "true" dimension on each of nineteen parts. The base line indicates the approximate size of the dimension and the code indicates the shape of the part measured.

study dealing with experienced toolmakers was set up in a plant engaged in the manufacture of precision parts for aircraft and automobile engines. In this study, 45 men were selected from the tool room. Their ages ranged from 17 to 62 years, their experience with the company from five to twenty-nine months, and their experience on their present jobs from one to twenty-nine months. For the most part, the job classifications of these men fall in higher labor grades than do those reported in the inspection department study.

The study was limited to the use of vernier micrometers and employed nineteen parts to be measured. Five parts were cylindrical, five rectangular, five spherical, and four were inside diameters. Here again, each employee measured each part independently five times and the reading

recorded was the best judgment he could make as to the "true" reading on the basis of these trials. After all readings had been completed by all of the men, the parts were measured with ultra-precision instruments and Johansen blocks in order to obtain the closest possible approximations to the "true" dimensions against which to compare the measurements made by the men.

Accuracy Results. No significant correlations were found between accuracy of measurement and either age, length of experience with the company, or amount of time on the present job. The percentages of accuracy are shown in Figure 2. On the baseline of this figure is plotted

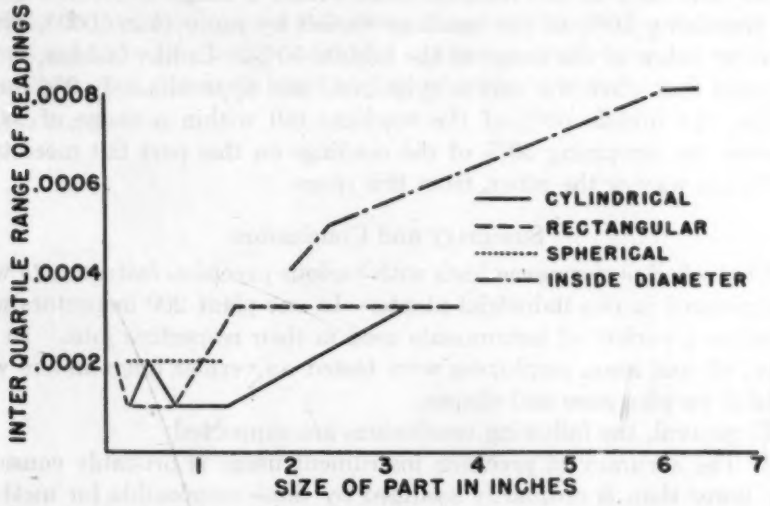

FIG. 3. The variability of the vernier micrometer measurements of 45 toolmakers on each of nineteen parts. The base line indicates the approximate size of the dimension and the code indicates the shape of the part measured.

the approximate size of the part. On the vertical axis is plotted the percentage of readings correct to .0001 inch. It will be noted that the parts vary in size from approximately ¼ inch to approximately 6½ inches. Each of the four lines plotted in Figure 2 shows the percentage of readings within .0001 inch of the "true" dimensions for parts of a certain shape according to the code indicated in the figure. Thus, for cylindrical parts, about ¼ inch in size, 73% of the readings were accurate to .0001 inch. For cylindrical parts approximately 3 inches in size, however, only 12% of the readings were accurate to .0001 inch.

Variability Results. The results plotted in Figure 2 assume the accuracy of the so-called "true" dimension. The validity of these "true" dimensions is always open to question in spite of the ultra-precision

methods used. Therefore the data were analyzed in another way to show the variability of the readings obtained without reference to the "true" dimensions. This analysis of the results is plotted in Figure 3. Here again the approximate size of the part in inches is plotted on the baseline. The vertical axis on this chart plots the interquartile range of the readings. This may be interpreted to mean the range of the middle 50% of the readings under each condition of size and shape of the part. For example, looking at the solid line plotted in Figure 3, it will be noted that when the part is cylindrical and approximately ½ inch in size the interquartile range of readings, or the middle 50%, is .0002 inch. This means that 50% of the readings were within a range of .0002 whereas the remaining 50% of the readings varied by more than .0002, either above or below of the range of the middle 50%. In like fashion, it will be noted that when the part is cylindrical and approximately 2¼ inches in size, the middle 50% of the readings fall within a range of .0003, whereas the remaining 50% of the readings on this part fall more than .0003, one way or the other, from this range.

Summary and Conclusions

Controlled performance tests with various precision instruments were administered in two industrial plants. In one plant 200 inspectors were tested on a variety of instruments used in their respective jobs. In the other, 45 tool room employees were tested on vernier micrometers with parts of varying sizes and shapes.

In general, the following conclusions are supported:

1. The accuracy of precision instrument usage is probably considerably lower than is ordinarily assumed by those responsible for methods and standards. In one plant the percentage of inspectors meeting the standard ranged from 66% on the use of the inside micrometer to 9% on the inside caliper in combination with the six-inch micrometer.

2. In the population studied, micrometer reading accuracy did not correlate significantly with age, amount of experience with the company, or length of time on the present job.

3. Gross size of the part is apparently a factor in the accuracy of micrometer measurement. Under optimal conditions in the second plant, not more than 80% of the readings were accurate to .0001 inch and with larger parts, ranging from 3 to 6 inches, only about 20% of the readings were accurate within these limits.

4. Gross size of the dimension is likewise related to the variability of measurements. As the parts increase in size, regardless of shape, the spread of the readings becomes greater so that for large inside diameters, 50% of the readings vary by .0008 inch from the other 50% of the readings.

5. The results suggest that while inside diameter measurements are more variable than measurements of cylindrical, rectangular, or spherical dimensions, the percentage of measurements meeting the standard of ±.0001 inch is no less. However, the problem of the relationship between shape and both accuracy and variability is open to further investigation.

6. The necessity for the development of training methods that will more nearly standardize judgments based on such characteristics as "feel," "tension," and "drag" in the use of precision instruments is indicated.

7. The implication is present that the very nature of the vernier micrometer and similar precision measuring instruments is such that one should not expect as high a degree of constancy as the average operator, supervisor, and standards man has been taught to expect.

Received November 29, 1944.

Movement Analysis as an Industrial Training Method *

Lawrence G. Lindahl

Division of Education and Applied Psychology, Purdue University

Many industrial jobs which involve coordination of hand and foot movements in operating machines present difficult training problems. Typical of such jobs is contact disc cutting. The company producing contact discs experienced considerable difficulty in training new operators because the majority did not complete the training and for those who did, learning was slow and uncertain. Preliminary investigation with experimental apparatus indicated that part of the difficulty encountered in training new operative personnel was due to the failure to identify the form of cutting movement necessary for "getting the feel" of satisfactory performance of the job.

The cutoff machine slices thin discs (e.g., .020″ × .150″ diameter with ±.002″ on both dimensions) from various sizes of tungsten rods with a rubber-bonded abrasive wheel .015 of an inch thick and six inches in diameter. The cutting wheel turns between closely fitted guides, moving up and down between the guides and across the rods being cut. The process is wet cutting and the wheel is not visible to the operator while cutting. Most machines cut two rods at a time.

The operator pushes the rods through guides into stops which regulate the thickness of the discs. Holding the rods firmly against the stops with a hand lever, he operates a pedal with the left foot which controls the cutoff wheel as it is applied to the rods. As soon as he cuts through the rods he lifts his foot, the wheel rises, and immediately after it has cleared the stops a backward jerk of the right hand actuates ejector or knock-out pins which knock the severed discs into the stream of water. Immediately after the ejection of the discs the rods are pushed back into the stops and a new cut is taken. Figure 1 shows an operator seated at a machine ready for operating.

The cutoff machine depends for successful operation upon the speed, form, rhythm, and pressure pattern of the hand and foot action of the

* Based upon a thesis submitted by Lawrence Gaylerd Lindahl to the Faculty of Purdue University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy, October 1944. Acknowledgment is due Dr. Joseph Tiffin and Dr. C. H. Lawshe who jointly directed the research and to James R. Brock who made the study possible in industry.

operator. Failure to apply foot pressure properly results in damage to the discs, excessive breakage and use of wheels, and wastage of material.

The purpose of this study was to analyze the disc cutting operation by identifying the form of the foot movement that produced satisfactory quantity and quality of discs with minimum cutting wheel usage, and to teach this form to new operators by the movement analysis method.

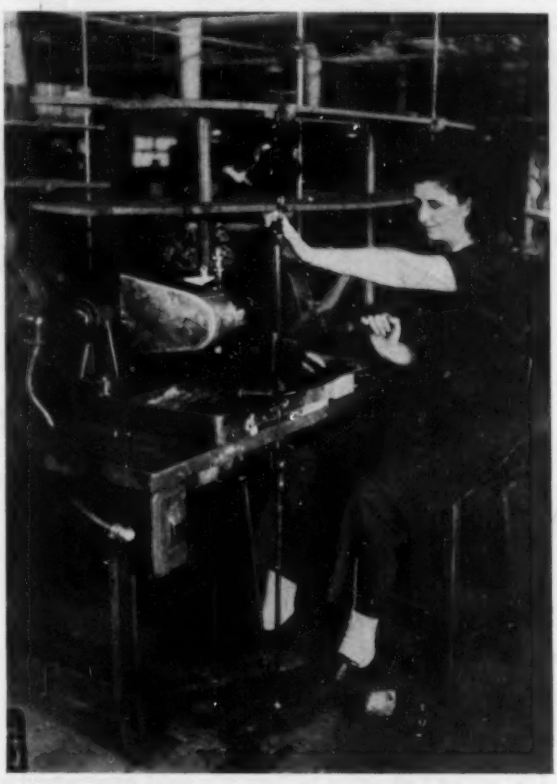

FIG. 1. An operator seated at the disc cutoff machine ready for operating.

The Method

The Apparatus. The mechanical apparatus used for the movement analysis included a paper tape recorder with a specially made writing arm attached. A fine thread was fastened to the writing arm and run through glass bushings mounted in metal pieces which were clamped at accessible places on the cutoff machines, and thence to the pedal in such a manner that the complete cutting cycle movement could be recorded on the paper tape as it moved along at a known speed under the pen.

The recorder was placed on a small wheeled table which was pushed from machine to machine and checks on operators were quickly and accurately made without interference with production. Figure 2 is a schematic drawing of the recorder attached to the cutoff machine.

Procedure. The procedure consisted first of a job analysis by activity. The principal activity, the cutting cycle, was further analyzed by studying the foot action recordings of skilled operators to find out what constituted good performance. The recorder was then used for instructional

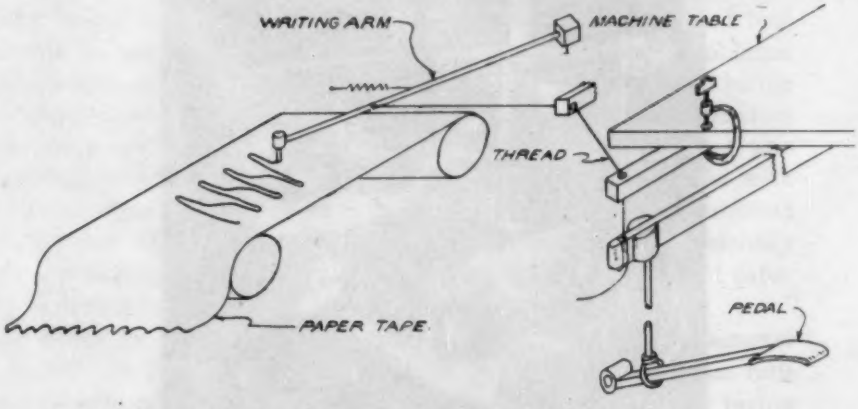

FIG. 2. Schematic drawing of the paper tape recorder attached to disc cutoff machine

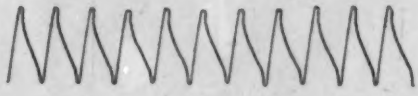

FIG. 3. Disc cutter foot-action pattern of a good, experienced operator. This was the accepted standard.

purposes in the training of new operators and for improving experienced operators already on the line. This type of analysis is not entirely new. It was utilized with good results by Tiffin and Rogers (5) in training tin plate inspectors and by English (1) in training riflemen.

The coordination of the foot action in cutting, with the hand action in placing the rods against the stops and ejecting the discs after cutting, constituted the cutting cycle. The cut through the rod was the cutting phase and the ejecting of the discs and placing of the rods against the stops was the recovery phase.

Since the foot action was the principal part of the cutting cycle, the main effort was given to finding the correct foot action pattern and then presenting it to the trainees in an effective manner.

By recording the patterns of experienced operators and supervisors, who were also experienced cutters, and comparing the action patterns with quantity, quality records, and abrasive wheel usage records, it was possible to identify the "standard" or correct pattern. There were wide variations in action patterns of the experienced operators showing the existence of individual differences, but the consistent pattern was there

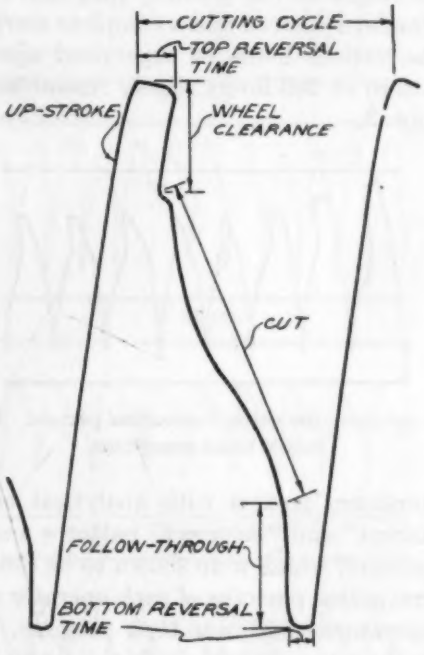

FIG. 4. An enlarged view of disc cutting cycle showing its principal parts.

to form the basis on which the noted differences could be explained, Figure 3 shows the foot action pattern accepted as standard. All sizes of rods gave the same pattern, but spacing of cuts was wider for large rods because of longer cutting time. The correct pattern showed a good reverse cutting curve which indicated unhurried, steady cutting with "feel" of rod. The operator checked his foot at the same place on every cut just as he cut through the rod by easing the pressure, thus allowing the wheel to cut its way through without making burrs. The short follow-through at the bottom indicated, in shop parlance, a "soft" foot. The recovery started soon after cutting through, saving time for each cut

and allowing plenty of time to coordinate or time the ejection of the discs and place the rods back against the stops ready for the next cut. The operator paced the machine and adjusted his time for the cutting part of the cycle to the speed at which the wheel could cut best without forcing or crowding the wheel. To force or crowd the wheel results in several disc defects, short wheel life, and wear out of the setup. Figure 4 is an enlarged view of one cycle showing the significance of each part of the cycle. Figure 5 is an incorrect pattern made by a trainee with only 4 hours experience. Figure 6 shows the foot-action patterns of one trainee at various stages in the training program. There is a steady approach to the standard pattern and a complete story is evident in each recording after the various hours of supervised operation. It will be noted that the pattern at 239 hours closely resembles the standard pattern shown in Figure 3.

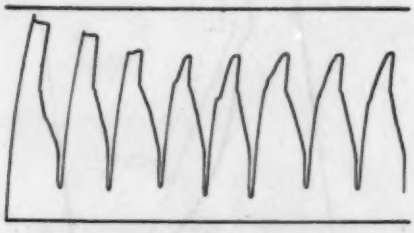

FIG. 5. An incorrect disc cutter foot-action pattern. Operator had only 4 hours experience.

Enlarged instructional posters with analytical notations were prepared both for "correct" and "incorrect" patterns and for various types of damage to the product which were shown to be reflected in the action pattern. Individual action patterns of each operator were kept in folder form also so the operators could note their progress. By careful use of the recorder at timely intervals with both the trainees and experienced operators and by interpreting the foot action patterns in terms of the standard, it was possible to reduce the training time of new operators and to improve the quality and quantity performance of some employees already on the job.

Results

Trainees Versus Old Operators

Training a group of operators on the production line is not unlike breaking in a team of horses, a group of men for a football team, or a squad for the army. All must work together. Especially is this true where the operators are working on day rate and a certain amount of

production must be obtained each day. One individual cannot do all the work no matter how good he is. The object of the training program is, therefore, to get all of the trainees as nearly alike as possible in the shortest time and all as good and as near like the standard as possible.

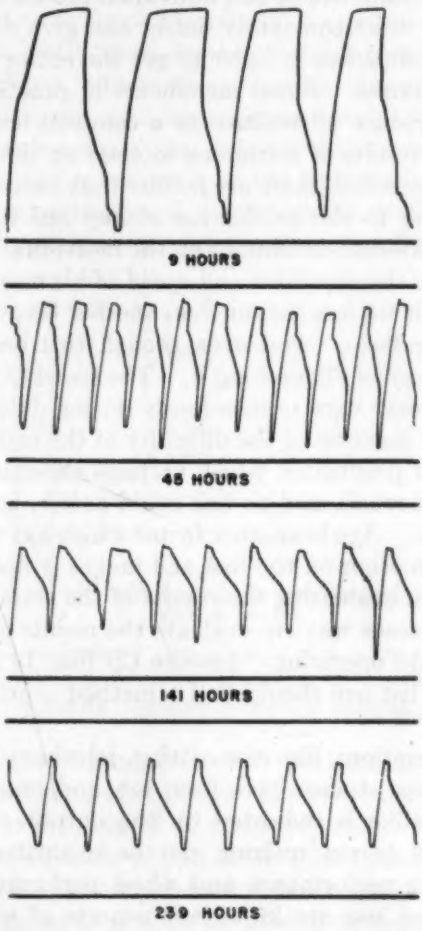

FIG. 6. Disc cutter foot-action patterns of a trainee showing improvement with training. The records were made after 9, 45, 141, and 239 hours of supervised operation.

The supervisor, or trainer, has to move from operator to operator, checking, helping, comparing, encouraging, correcting, explaining, and expecting progress day by day. If he does not maintain his own interest he will not find continued interest in the learners, especially after the newness of the job has worn off. He should be interested in the group;

it is from the group that he expects to obtain production. It is, therefore, on the group that the training program must be evaluated. Even when all possible attention has been given to the group, individual differences will remain. Tiffin (6) enumerates many kinds of individual differences in job qualifications and individual productivity. The person doing the training must constantly detect and give due consideration to these individual differences in order to get the entire group to the stage of perfection he desires. Equal increments of practice and training do not in any sense reduce all trainees to a common level of performance. In evaluating the results of a training method on the job where none of the variables is controlled, there are factors that prevent one from giving too much attention to the production of any one individual. For instance, there are external limitations on the individual's power to increase his output, such as the condition and speed of his machine. One trainee may be given credit for less output than another because he was carrying an undetected handicap. And even though this handicap is detected there is often no way of eliminating it. The speed of two machines that look exactly alike may vary tremendously during different periods of the day; or supplies of material or the difficulty of the task may set an upper limit on individual production which perhaps one-third of the members of the group could reach, and no one could better, no matter how competent he might be. Age is another factor which has unmeasured effects on individual production on the line and makes it necessary to consider group differences in evaluating the results of the training program.

There are numerous ways to evaluate the results of the training once it has been put into operation. Lawshe (2) lists 13 methods and from such an extensive list one should find a method that fits any particular case.

In machine operations, like disc cutting, jobs have been time-studied, rates based on these studies have been set, and production of trainees and old workers alike is indicated by the output. In the particular operation reported herein training can be evaluated on two factors, namely, production performance and wheel performance. Both wheel breakage and wheel use are important aspects of wheel performance. The two factors are considered to be of equal importance and management has set up a rate sheet based on the number of cuts secured per wheel for a given size of rod and the speed of cutting (production per hour). In other words, the operator must get a specified number of cuts per wheel and must cut at such a speed that he will turn out enough units in one hour to earn the base rate set per hour. When he gets the exact number of cuts per wheel for the rod size he is cutting and cuts just enough to earn his hourly rate, he is doing 100% performance in both factors, namely, production performance and wheel performance.

There are several reasons for emphasizing wheel performance. One is that the special type of wheel used for tungsten disc cutting is very expensive and wheel costs can very easily exceed labor costs. Also, a better quality of product is obtained by limiting the speed of cutting, which is effectively done by placing emphasis on wheel performance.

Curves are used to evaluate the effects of this training program. As stated by Tiffin (6, 186), "such curves, therefore, serve the very useful purpose of providing a means of evaluating the successfulness of an operator-training program and spotting decisively those operations in which training is inadequate, either in quantity or quality."

Figure 7 is the production curve of the trainees for 12 weeks. Production performance percentage is plotted on the vertical axis and weeks (6 days each) of training on the horizontal axis. Production perform-

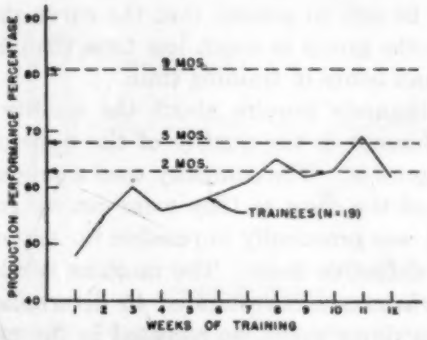

FIG. 7. Production performance percentage of disc cutter trainees. Dotted lines represent average production performance percentage for first 2 weeks of groups with an average of 2, 5, and 9 months experience at start of training.

ance percentage makes the production performance of all operators comparable since it is computed on the company rate sheet for the various sized rods cut. For instance, if an operator using 6" wheels to cut .142 inch rods, cuts 12,000 units of rod in 10 hours, he cuts at the rate of 1,200 units per hour. The rate sheet indicates the operator should cut 2,340 units per hour to earn the base rate of 65 cents per hour. Since 1,200 is 51 per cent of 2,340, his production performance is 51 per cent. The production performance percentage is, therefore, the average number of units cut per hour divided by the number of units that the operator is expected to cut per hour of the size rod being cut to earn his wage.

The dotted lines in Figure 7 show the production performance of old operators at the start of the training experiment. There are three groups of these old operators. Before the training started, eight operators had an average of 2 months, nine operators had an average of 5 months, and

ten operators 9 months experience on the job. The trainees had no previous experience. Old operators total 27 and trainees 19. No data were available on the production abilities of the various groups prior to the start of training. In order to obtain a basis of comparison for the groups, an average of the production of the first two weeks at the beginning of the training is considered indicative of the ability of the groups of old operators at that time. These averages are shown on the figure by the dotted lines.

The production curve for the trainees reflects a steady rise. At the end of 8 weeks they have surpassed the average of the 2 months group. At 11 weeks they exceeded what the 5 months group was able to do at the beginning of the training program. Although their average fell on the 12th week, this is not unusual in curves of this type. The general trend is upward and with more confidence, experience, and continued training it should be safe to assume that the curve should reach the top limit of the 9 months group in much less time than 9 months, resulting in saving many man hours of training time.

One may legitimately inquire about the quality of the discs cut. There was no difference in the quality of the discs cut by the trainees and by the other groups. The company used a production checker who continually checked the discs as they were cut by going from operator to operator and it was practically impossible for any one operator to cut a majority of the defective discs. The machine would be shut down or the operator's performance investigated to determine the cause of the defects. Any shut down would be reflected in the production performance of the particular operator. Since tungsten is an expensive material, it was imperative to keep wastage at the very minimum. One hundred per cent inspection of the discs was made after a tumbling operation, but this was done according to size of discs and the production of two or three operators cutting the same size rods was usually thrown together. Production control regulated the quantity to be cut over any one period. In the form of stricter supervision this control probably served as a forced incentive to the worker.

Figure 8 is the wheel performance percentage plotted against weeks of training. The averages of the 2, 5, and 9 months groups of old operators in wheel performance are shown by the dotted lines. These averages are of the first two weeks performance at the beginning of the program. Wheel performance percentage is computed from the rate sheet. Referring to the illustration previously cited, if the operator who cut 12,000 discs in 10 hours used, without breaking, 20 of the 6″ wheels and broke 5 others, he used a total of 25 wheels to cut 12,000 discs. He obtained 480 units per wheel. According to the rate sheet, 100 per cent

wheel performance on .142 rod requires 470 units per wheel. The wheel performance is 480 divided by 470 or 104 per cent. Wheel performance is, therefore, the units the operator gets from each wheel divided by the number he should obtain according to the rate sheet for the size of rod being cut. Wheels broken must be counted as wheels used, for the operator gets some cuts with the wheels before they are broken. Wheel performance is negatively correlated with production performance. The faster the cutting the higher the production and the fewer units per wheel. This relationship had to be regulated in the training program and emphasis placed on cutting according to the cutting curve so that both maximum wheel performance and maximum production were obtained.

The rate sheet is made up on the basis of 100 per cent production performance and 100 per cent wheel performance. Figure 8 shows the 9 months operators at exactly 100 per cent wheel performance while

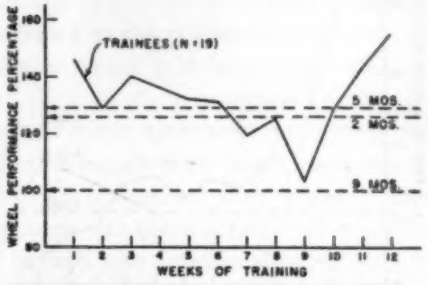

FIG. 8. Wheel performance percentage of disc cutter trainees. Dotted lines represent average wheel performance percentage for first 2 weeks of groups with an average of 2, 5, and 9 months experience at start of training.

Figure 7 shows their production performance at 81 per cent. It will be observed by reference to Figures 7 and 8 that the trainee curve goes up toward 100 per cent production performance and downward toward 100 per cent wheel performance.

One must speculate on the sudden upturn in the wheel performance curve of the trainees after the 9th week. It can be accounted for to some extent at least by the fact that a more rigid accounting of wheels used was started at that time. Some operators had acquired the habit of not using all the wheel because of the slower cutting pace due to the smaller diameter of the wheel as it wore down. These operators changed wheels before entirely using them. This lowered the wheel performance and took more wheels. By requiring operators to turn in every used wheel for inspection at the end of the day's run it was possible to determine just which operators had not entirely used their wheels. The general effect was that all operators tended to use up their wheels, thus

getting higher wheel performance. This might also cause the slightly lower production because of slower cutting as the wheel grew smaller.

The best operator would get as much over 100 per cent wheel performance and as much over 100 per cent production performance as possible. To do this he would have to cut steadily, consistently, and carefully during all working time. Failing to do this he could not possibly get over 100 per cent wheel performance even though he might cut fast to make up lost production time, because the faster he would cut the lower his wheel performance would become. The interrelationship of wheel performance to production performance complicated the training problem and made the movement analysis method all the more important.

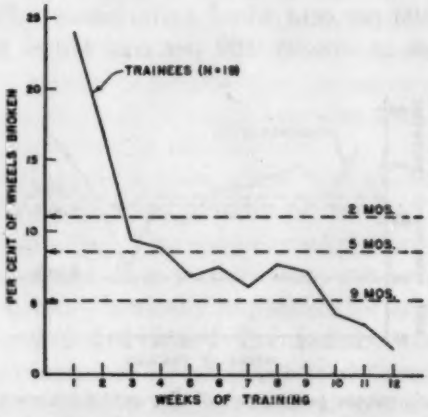

FIG. 9. Percentage of wheels broken by disc cutter trainees. Dotted lines represent average percentage of wheels broken for first 2 weeks by groups with an average of 2, 5, and 9 months experience at start of training.

As has been noted, this found a standard pattern that laid stress on both accuracy and wheel performance.

Figure 9 shows the percentage of wheels broken plotted against weeks of time. Percentage of wheels broken is the fraction of the total number of wheels used each week. For instance, the number of wheels used without breaking plus the number broken is the total number used. The ratio of the number broken to this total is the percentage broken. If, for example, an operator wore out 300 wheels in one week and broke an additional 25, he used a total of 325 wheels. The percentage of wheels broken during the week is 25 divided by 325, or 7.7.

Figure 9 shows graphically the trainees' reduction in wheel breakage due to the attention given to the correct cutting method. During the first week the trainees broke 24 per cent of their wheels. By the third week they were breaking less than operators having 2 months experience,

by the 5th week less than those having 5 months experience, and by the 10th week less than those having 9 months experience. By the 12th week of training the trainees broke only 1.8 per cent of their wheels, or about one-third that of the group with 9 months previous experience. This is good for two reasons; first, because the wheels were very expensive and large savings resulted (wheel cost could very easily exceed labor cost), and second, all time taken to change broken wheels has to be charged against production time. Broken wheels prevent running for a period ranging from one minute to sometimes as long as a half hour, depending on how long it takes to remove the broken pieces from between the guides.

The higher average wheel performance noted for the trainees is due to emphasis being placed on accuracy rather than speed and on correct operation, or cutting according to the reverse cutting curve. High wheel performance eventually leads to increased production. It insures a better quality of product at the beginning with less wastage. The curve shows that the trainees steadily reduced their wheel breakage. In Figures 7, 8, and 9 the trainees show exceptionally fine performance in relationship to the other three groups of operators who learned by the "pick-up" method. Although their production average was lower than the 9 months group of operators, they steadily increased production, their wheel performance was maintained well over 100 per cent, and the per cent of wheels broken was considerably reduced.

Trainees Versus Beginners

Another way operators learn jobs, probably more prevalent than any other learning method in industry, is that of "trial and success." This consists of showing the operator his job and then "turning him loose" to learn in the best way he can. It is a sort of "sink or swim" proposition. The operator is not led from the beginning by progressive steps and has no reliable indication of his progress. Such haphazard learning usually results in lower efficiency and poor work habits.

It was possible to obtain records over a period of three weeks of the production and the wheel performance of 5 operators who were learning the disc cutting operation in just this manner. They are called beginners for purposes of comparison with the trainees who were trained by an organized method. These beginners did not have the advantage of using the movement analysis recorder nor any of the instructional material.

Figures 10, 11, and 12 present a comparison of the production performance, wheel performance, and wheel breakage of beginners and trainees at the end of the first, second, and third week of operation on the

job. Figures 10 and 12 do not show a significant difference between the two groups in production performance and percentage of wheels broken. Figure 11, however, shows graphically considerable difference in wheel performance percentage between the two groups. Whether the difference shown can be attributed to chance can be tested statistically by finding (t) the significance ratio for the difference in the means of two

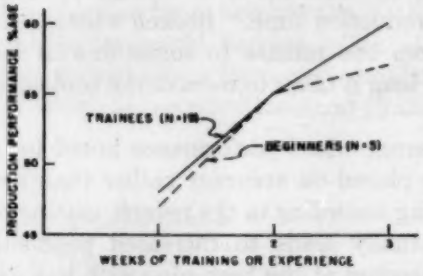

FIG. 10. Production performance percentage of disc cutter trainees and beginners for first three weeks.

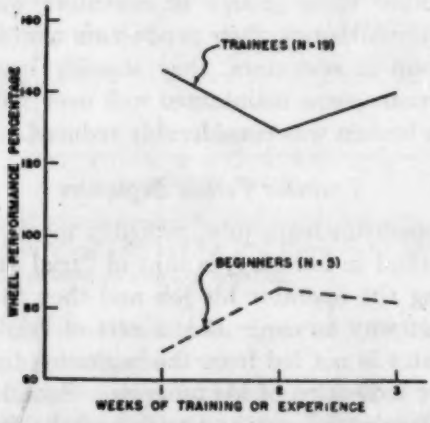

FIG. 11. Wheel performance percentage of disc cutter trainees and beginners for first three weeks.

independent small random samples. The smallest difference between the two curves occurred at the second week. The significance of this difference, therefore, was computed to determine the possible role of chance in accounting for the difference between the curves. The second week of training or experience shows a wheel performance percentage mean of 129 for the trainees and 86 for the beginners. Substitution in the formula (3) for finding the significance ratio for the difference in the means of two independent small random samples results in a "t" of 2.548.

Reference to the table of *t*'s indicates a "*t*" of 2.518 for 21 degrees of freedom is required for the 2 per cent confidence level. The obtained difference is therefore significant at the 2 per cent level which means that there are 98 chances in 100 that the difference found is not due to chance and must therefore be due to the special training given the experimental group.

Effect of Training Program on Old Operators

When any training is carried out directly on the production line it is bound to have some effect on the experienced operators even though most of the attention is directed to the trainees. Studies have been made of factory workers in which work conditions of all kinds were varied. A noteworthy example is the experiment carried out in the Hawthorne plant of the Western Electric Company (4). Its most impor-

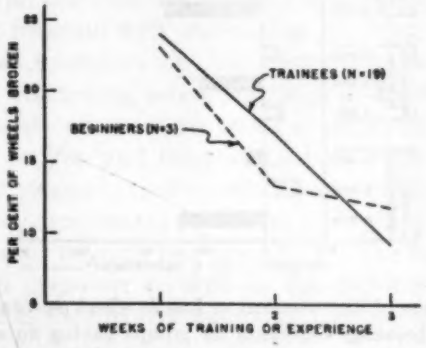

FIG. 12. Percentage of wheels broken by disc cutter trainees and beginners for first three weeks.

tant finding was that regardless of the nature of the changes made in the working conditions the productivity of the experimental group tended in general to increase. Although the interest and attention undoubtedly had a stimulating effect on the old operators, the fact that foot-action recordings and interpretations were made for them as well as the trainees would lead one to believe that interest and attention did not account for the total improvement.

One cannot rush up to an old operator with a new gadget with the expressed purpose of checking up on him. The cooperation of the old operator may be secured, however, by explaining to him the need for finding out how the job is done so that it can be taught to the new operators. Practically every old operator will give the best performance he can muster up and is then already on the road to self improvement. One can also question the operator about his work. As soon as the old

operator finds that someone is interested in his job he begins to think that the job is important after all and he is likely to take more interest in his work and that of fellow workers. Learning becomes contagious, production starts to increase, the entire line improves, and no one but the person in charge of the training is aware of it or knows the reason why.

If those operators who seem not to want help are ignored for a while they will soon seek help either by asking for a recording or by letting it be known that their recordings have not been taken. Workers all desire to be treated alike.

A review of the foot-action patterns [1] shows that old operators used a lot of waste motion in cutting and most of them had not developed the

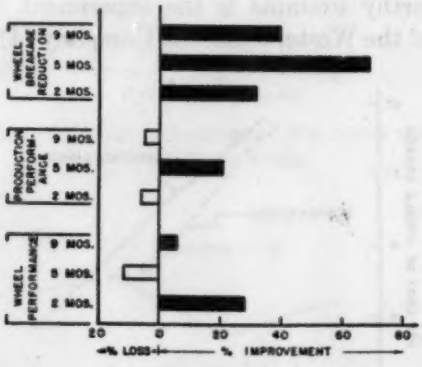

FIG. 13. Percentage of improvement or loss in wheel performance, production performance, and wheel breakage reduction for groups having an average of 2, 5, and 9 months experience on the disc cutoff machine prior to the start of the training program.

necessary "feel." That they could improve by watching the recorder was also shown.

Figure 13 shows the percentage of improvement or loss in wheel performance, production performance, and wheel breakage reduction made during training by groups having an average of 2, 5, and 9 months of experience on the disc cutoff machine prior to the start of the program. The graph is based on averages for the first three weeks and the last three weeks of the training period. In computing the percentage of improvement or loss, the performance at the start of the program was considered 100 per cent.

All three of the groups broke fewer wheels after the training was under way. The 5 months group made the greatest improvement by breaking 69 per cent fewer wheels than they did at the start, the 9 months group

[1] Case studies and complete presentation of data will be found in the appendix of a thesis by the author on file in the library of Purdue University.

40 per cent less, and the 2 months group 32 per cent less. Reduction in wheel breakage effected a substantial saving in wheel costs over the period.

The 5 months group improved their production performance 21 per cent but suffered a loss of 11 per cent in wheel performance. Since production performance is negatively correlated with wheel performance and both are of equal importance, this represents total improvement and reflects the emphasis placed on wheel performance by the movement analysis method. Likewise the 2 and 9 months groups improved their wheel performance by 28 and 6 per cent, respectively, at the expense of production by only 6 and 5 per cent. Again with wheel performance and production performance of equal importance this represents substantial improvement.

The total picture is good when one considers the nature of the operation, that it is a hand and foot coordinated operation which requires the human operator to function with mechanical precision over long periods of time, and that old operators may have learned as many bad habits as good, necessitating unlearning before starting new habits.

That these experienced operators could so effectively cut down in the number of wheels broken and improve in both wheel and production performance at this stage of experience indicates that learning of a better cutting cycle by old, experienced operators took place with the installation of the program for training new operators. The improvement made by the experienced operators as well as the trainees seems to justify movement analysis as an effective industrial training method.

Summary and Conclusions

The problem of training rapidly a number of new workers to operate certain type of cutoff machines used for cutting tungsten rods into small discs for electrical apparatus has been explained. A method has been described which analyzes the foot movement of the operator by the recording of a pattern on a moving paper tape. A standard pattern was established and the recorder was used to take recordings of the trainees at frequent intervals. These recordings were explained on the basis of the standard. Various defects in the product were identified with the foot movement patterns and many individual differences in both old and new operators were noted and described as clinical case studies. Finally, complete production records of all operators were kept. These records were plotted in graphical form to show the progress of the various groups at different stages of training.

In general, the findings warrant the following conclusions:

1. The disc cutting operation was analyzed by activity and the best form of cutting movement identified.

2. The cutting movement of the operators was shown in graphic form, compared with a standard, and used as an effective training method.

3. Training time was effectively reduced. At 8 weeks the production performance percentage of the trainees was better than that of old operators who had had the same average amount of experience by the "pick-up" method.

4. Trainees, who were taught to use the cutting wheel by studying the movement analysis recordings, secured better wheel performance than old operators.

5. Trainees reduced their wheel breakage in a few weeks to a point much lower than the average of old operators at start of training program.

6. Trainees did better in wheel performance than beginners who learned by the "pick-up" method.

7. Experienced operators benefited by the training program.

8. It is entirely possible that equally successful improvements in training could be made in numerous other manipulative jobs by the application of a similar method of recording graphically the performance of the operator.

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Military Job Evaluation: Army Air Forces *

Arthur O. England, Captain, Air Corps**

During the early stages of 1942 and 1943, when the reception centers were bulging with incoming men, the paramount problems facing the classification and personnel officers were the initial classifying of these men, fulfilling the technical school quotas and inaugurating on-the-job training necessary to build efficiently operating tactical units. Little or no information was available on the subject of effective utilization of manpower. Job evaluation, by any method, was non-existent—or if existent, at least it was not available for general consumption by military personnel.

A War Department Memorandum [1] issued in January 1943 stated in part that many enlisted men in the Army Air Forces who have been trained as technicians in the various Army Air Forces Technical Schools, were being employed on jobs which did not require special training or special qualifications and which were appropriate for unskilled privates only. The Inspector General's Department assumed some of the responsibility for detecting and reporting to the War Department personnel misplacement and attendant wastage. Further, every Air Force or Command established a special unit known as Classification Audit Teams, whose function it is to inspect periodically each installation in that Command for proper classification, assignment and personnel utilization. These teams are composed of officers who possess extensive experience in Military Classification and Assignment.

In an effort to control the reclassification [2] of these highly trained technicians, Headquarters, Army Air Forces, issued a Memorandum [3]

* This Research Project was conducted during 1943 under the general supervision of Col. Alvin L. Prichard, Asst. Chief of Staff, A-1, Army Air Forces Eastern Flying Training Command.

** Capt. Arthur O. England is Officer in charge of Classification Research Section, Army Air Forces Eastern Flying Training Command.

[1] War Department Memorandum No. W615–9–43, Adjutant General's Department, January 22, 1943.

[2] Reclassification is a term used to describe any change in the classification of the incumbent. It may be downward (representing less utilization of the individual's capabilities), upward (representing greater utilization of the individual's capabilities) or lateral (representing less utilization of the individual's capabilities, but in a different field of skill). Insofar as we are concerned in this article, reclassification will be construed to mean downward reclassification.

[3] Army Air Forces Memorandum No. 35–16, January 22, 1943.

making all reclassification subject to approval of a specially appointed Board of Officers (one of whom must be a Classification and Assignment Officer), at every Air Forces Air Field or similiar installation. Evidence must be established during the board meetings to the effect that the proposed reclassification of an incumbent will be of benefit to the Army Air Forces. Such reasons as: physically incapable of performing duties of the old job, proved inefficiency by actual on-the-job trial, or the incumbent's qualifications are needed to perform in a more critically needed job specialty, would justify reclassification.

Although this established control medium has, to a large extent, prevented wholesale malassignment and inefficient personnel utilization, the evaluation of each individual case appearing before the Classification Board was dependent ultimately upon the local, subjective interpretations of the values of the military jobs by the Board.

Job specifications of Military Occupational Specialties are, by necessity, designed for flexible interpretations to provide a method whereby an individual, performing duties on various types of equipment, peculiar to each Air Force or Command, can qualify as a specialist in this one general job. For example, there is one set of job specifications for Airplane Mechanic. However, the Airplane Mechanic who has been trained on a four-engine Flying Fortress is definitely a higher skilled mechanic and can perform a greater variety of mechanical duties than can a mechanic who has been trained on a single engine Primary Trainer Airplane. Both, however, receive the same rating of Airplane Engine Mechanic.

It was because of the above instances of a lack of any standardized method of evaluating Army jobs, along with the relatively high degree of subjective interpretations that has been entering into the problem of reclassification and personnel utilization, that the publication "Job Evaluation for Army Military Occupational Specialties," [4] appeared December 18, 1943. The problem at hand was to provide a means of establishing standardized values for different Army jobs for the purpose of ascertaining efficient utilization of available manpower.[5]

Procedure: A Factor Analysis

An attempt was made to identify all of the possible factors for a job analysis. Nine significant items were finally selected and retained in the rating scale. Each item is divided into six component parts, with a numerical value assigned to each. The numerical value of each item de-

[4] Job Evaluation for Army Military Occupational Specialties, developed by Capt. A. O. England, Headquarters, AAF Eastern Flying Training Command, Classification Research Section, Maxwell Field, Alabama.

[5] It should be noted here that the publication of "Job Evaluation for Army Military Occupational Specialties" was intended to serve solely as a "guide" and does not represent an official publication by the War Department.

Table 1

Factor Analysis and Point Values on Job Rating Scale

Items	0	1	2	3	4	5
Educational Requirement	None	Grammar Sch.	High Sch. Grad.	Some College	College Grad.	Post Graduate
Civilian Experience	None	2 Months	6 Months	1 Year	3 Years	5 Years and Over
Training Time on-the-job	3 Wks. and Less	1 Month	3 Months	6 Months	9 Months	12 Months and Up
Army Tech. School (Length of course)	None	6 Wks. and Under	8–10 Wks.	12–14 Wks.	16–18 Wks.	20 Wks. and Up
Intellectual Requirement by AGCT Test Score (min.)	None	Below 69	70 to 89	90 to 109	110 to 129	130 and Up
Skill	None	Passable	Fair	Good	Excellent	Superior
Supervisory Capacity (No. men supervised)	0–4	5–9	10–19	20–39	40–79	80 and Up
Nature of Work	Routine	Passable Empl. of Ingenuity	Average Empl. of Ingenuity	Good Empl. of Ingenuity	Excellent Empl. of Ingenuity	Superior Empl. of Ingenuity
Equipment Used on Job	None	Simple: Hand Tools, Saw, Drill, etc.	Complex: Teletypewriter, Typewriter, Testing Set, etc.	Very Complex: Comptometer, Flexible Guns, Key Punch	Intricate: Radio, Power Turret	Very Intricate: Radar, Bombsight

pends upon its relative position in the table (Table 1), i.e., the level of difficulty, or the higher the requirements, the higher the point value assigned to each item. The point value range extends from 0 points to a maximum of 5 points. This range was arbitrarily agreed upon. It could have been 0 to 50, or 10 to 100, or any progression of numbers.

In the selection of differentiating items, one very significant item had to be discarded, namely wage scale. Unlike most civilian rating scales, pertaining to the job, which are usually weighted heavily, the Army does not adhere to any specific wage scale for military jobs. That is to say, a soldier's grade (Private, Sergeant, etc.) does not necessarily prohibit him from performing any military job. Because of a multitude of factors influencing the promotion of enlisted men, it has been impossible to correlate any job to a particular grade. There are numerous instances of Sergeants working for Corporals because the Corporals are more qualified by reason of proven experience on certain type aircraft than other soldiers of higher grade.

Items to be Rated

a. Educational Requirement: The range extends from none to Post Graduate. Even though exact information on educational requirements is obscure for any military specialty, the majority of specialties have some minimum requirement, either clearly established in AAF Regulation 50-12 or arrived at by a consensus among those individuals exercising supervisory jurisdiction, even the particular military specialties. Point values assigned to the educational levels are indicated in Table 1.

b. Civilian Experience: There are a few selected jobs in the Army that require civilian experience of varying degrees. Factors influencing the awarding of point values to this item are the existence or absence of similar training in the Army. Tabulating machine operators, office machine servicemen, and psychological assistants are examples of military specialties that require a civilian background in that specialty before assignment to the specialty is made. Point values are assigned according to the time spent gaining experience in that specialty in civilian life.

c. Training Time on the Job: A consensus among competent personnel was used to assign point values for the "average" time spent becoming skilled in the specialty.

d. Intellectual Requirement,—By Minimum AGCT Score: [6] Once again, in those instances where the AGCT Score requirements are not clearly prescribed by regulations, such as the AGCT requirements for attendance at Technical Schools, a consensus among competent personnel was obtained. Point values assigned to this item are broken down according to the five groupings of AGCT Scores.

[6] AGCT: Army General Classification Test.

e. Skill: This represents a combination of aptitude and acquired talent. Perhaps this is one of the weaker items in this factor analysis because of the difficulty involved in rating the "skill" employed in each military specialty. A point of issue may very justly be taken on the line of demarcation between "passable" and "fair" skill. The extremities of this range are relatively clear; Kitchen Police, requiring "no" skill, and IBM Machine Repairman, requiring "superior" skill, are cited as examples of the extremes of the point value range. It was only after constant comparison of all factors involved in the performance of each job that the ensuing ratings in the item were arrived at.

f. Supervisory Capacity,—Number of Men Supervised: The point values assigned to this item are not dependent upon the number of men one has jurisdiction over, but rather the number of men one directly supervises and is responsible for in the exact performance of his job.

g. Nature of Work: The range of this item is from "routine" to "superior employment of ingenuity." Here, creativeness, originality and independent responsibility are evaluated.

h. Equipment Used on the Job: No particular difficulty was encountered in placing the proper point values to the breakdown of the scale in this item. The range extends from none to very intricate.

The difficulty of all rating scales lies in the proportionate point value assigned to each component part of each item. Which items shall be weighted the most, which the least, will depend upon a general consensus among those people who are cognizant of the job requirements being considered. That does not necessarily represent an inherent weakness in Rating Scale theory, but rather a weakness in our knowledge of the requirements of Army jobs.

Factor Analysis of Military Specialties Authorized for Use in the Army Air Forces

In this section, a factor analysis of Military Occupational Specialties has been performed by items on the basis of Family Groupings of jobs. The total points awarded each Military Specialty have been rated by the rank difference method. The relative rated position each specialty holds to each other is indicated in the column entitled "Final Rated Positions." The jobs have been arranged in a series, with the range extending from the highest evaluated job to the lowest evaluated job.

Not only is the "Final Rated Position" important in the evaluation of a job, but also the actual total point difference between the evaluated jobs should be given consideration. This becomes at once apparent when comparisons are made among Military Specialties on Single, Twin and Four Engine Airplanes, and when interchange of jobs among different Family Groups is attempted.

Table 2

Job Evaluation Ratings of a Sample of Five Military Job Groups

SSN	Job Title	Educational Requirements	Civilian Experience	Training Time on the Job	Army Tech. School	Intellectual Requirement	Skill	Supervisory Capacity	Nature of Work	Equipment Used on the Job	Total Points	Final Rated Position
					Administrative and Clerical Group							
826	AAF Supply Technician	1	0	4	0	3	2	1	3	0	14	7
821	QM Supply Technician	1	0	4	0	3	2	1	2	0	13	8
405	Clerk, Typist	2	2	2	0	3	2	0	2	2	15	6
275	Classification Spec.	2	0	4	1	4	4	0	4	0	19	3.5
055	Clerk, Non-Typist	2	0	2	0	3	2	0	2	0	11	9
056	Postal Clerk	1	0	2	0	3	1	0	0	0	7	13
274	Public Relations Spec.	3	3	3	0	4	4	0	4	0	25	1
213	Stenographer	2	2	2	0	3	3	0	2	2	16	5
835	Supply Clerk	1	0	3	0	3	1	0	1	0	9	11
502	Administrative Spec.	2	0	4	0	4	4	2	4	2	22	2
623	Financial Typist Clerk	2	2	3	0	4	3	0	3	2	19	3.5
348	Parts Clerk, Auto.	1	0	3	0	3	1	0	2	0	10	10
667	Message Center Clerk	1	0	2	0	3	1	0	1	0	8	12
					Armament and Ordnance Group							
911	Airplane Armorer	1	0	3	2	3	3	0	2	3	17	4
612	Airplane Armorer-Gunner	1	0	4	3	3	3	0	2	3	19	7
511	Armorer	1	0	3	0	3	2	0	2	1	12	5
683	Bombsight Mechanic	1	0	4	5	4	5	0	5	5	29	1
901	Munitions Worker	1	0	2	0	2	0	0	0	0	5	6
678	Power Turret and Gunsight Mechanic	1	0	5	3	3	4	0	3	4	23	2

Table 2 (*Continued*)

SSN	Job Title	Educational Requirements	Civilian Experience	Training Time on the Job	Army Tech. School	Intellectual Requirement	Skill	Supervisory Capacity	Nature of Work	Equipment Used on the Job	Total Points	Final Rated Position
	Airplane Maintenance Group (Based Upon Four Engine Planes)											
689	Airplane Cable Mech.	0	0	2	0	3	1	0	1	1	8	15.5
685	AP Elec. Mechanic	1	0	4	5	3	3	0	3	2	21	3.5
528	AP Hydraulic Mechanic	1	0	4	1	3	3	0	3	2	17	9
686	AP Instrument Mechanic	1	0	4	5	3	3	0	3	2	21	3.5
750	AP Maint. Technician	1	0	5	4	3	5	5	5	4	32	1
684	AP Power Plant Mech.	1	0	4	5	3	3	0	3	1	20	5
687	AP Propeller Mech.	1	0	4	5	3	3	0	2	1	19	6.5
555	AP Sheet Metal Worker	0	3	3	0	3	2	0	2	1	14	11.5
550	Airplane Woodworker	1	0	3	0	3	2	0	2	1	12	13
747	AP and Engine Mech.	1	0	3	4	3	2	0	2	1	16	10
548	Fabric and Dope Mech.	0	0	2	0	3	2	0	2	1	10	14
748	AP Mechanic-Gunner	1	0	5	5	3	3	0	3	3	23	2
665	Fuel Cell Repairman	1	0	4	4	3	3	0	2	1	18	8
559	Glider Mechanic	1	0	3	2	3	2	0	2	1	14	11.5
114	Machinist	0	3	4	0	3	3	0	3	3	19	6.5
256	Welder, Combination	0	0	3	0	2	1	0	1	1	8	15.5
	Transportation Group											
014	Auto Equip. Mech.	1	3	2	0	2	2	0	2	1	13	1
345	Auto Equip. Operator	0	0	2	1	2	0	0	0	1	6	4
932	Special Vehicle Opr.	0	0	2	1	2	1	0	1	1	8	2
931	Heavy Auto Equip. Opr.	0	0	2	1	2	0	0	1	1	7	3
	Chemical Group											
870	Chemical Tech.	2	0	4	3	4	3	1	4	3	27	1
809	Decontamination Equip. Opr.	2	0	3	2	3	2	0	2	3	17	2
786	Toxic Gas Handler	1	0	2	2	2	2	0	1	3	13	3

In this article, only five Military Job Groups have been presented. Actually, all the existing pertinent Army Air Force jobs have been evaluated in their respective Family Groups. In addition to the distinct Family groupings of jobs, one other Group, known as the "Miscellaneous Group," was brought into play. This Group represents a heterogeneous grouping of military jobs. Actually, many different family groups are represented and because they are, it was impossible to differentiate them by the factor analysis method. Examples of jobs falling into this grouping are Bricklayer, Laundry Technician, Translator, Bandsman, Dog Trainer, etc. Interchange of duties within this miscellaneous group will be dependent upon the discretion of the Classification Board after a careful study has been accomplished on the proposed transfer.

Index for Evaluated Military Occupational Specialties

The evaluated jobs were prepared in a readily accessible list. This listing, by family groups, shows the different jobs by their degree of "over-all" difficulty. Reference may be made to the index of evaluated jobs under the following circumstances:

(1) To ascertain if one job is upgraded or downgraded relative to another in the same family group.

(2) To ascertain the correctness, from a classification standpoint, of proposed new duty assignments in relation to the present duty assignment.

(3) To ascertain the validity of reclassifying an enlisted man from one Military Occupational Specialty to another.

(4) To reallocate enlisted men efficiently within a Command.

The interchange of jobs from one family group to another has always presented a challenging problem to the Classification and Assignment Officers. However, until such time as an evaluating scale has been devised whereby family grouping jobs may be compared, it appears highly improbable that a valid comparison can be made between the total awarded points of a specialty in one family group to the total awarded points of a specialty in another family group. A specialty requiring a high degree of mechanical skill, thus being rated highly in the evaluated job scale, cannot be compared adequately, say to a particular clerical job requiring a high degree of creativeness.

Preparation of a Reallocation Adjustment Table

An attempt has been made to prepare a reallocation adjustment table to be used as a guide in the reallocation of enlisted men by the qualifications in a particular Military Occupational Specialty, between single, twin and four engine flying schools.

The Personnel Divisions of any Air Force headquarters have from

Table 3

Index for Evaluated Military Occupational Specialties: Final Listing of Rated Jobs by Level of their Difficulty

SSN	Job Title	Total Points	Final Rated Position
	Administrative and Clerical Group		
274	Public Relations Specialist	25	1
502	Administrative Specialist	22	2
275	Classification Specialist	19	3.5
623	Financial Typist-Clerk	19	3.5
213	Stenographer	16	5
405	Clerk-Typist	15	6
826	AAF Supply Technician	14	7
821	QM Supply Technician	13	8
055	Clerk, Non-Typist	11	9
348	Parts Clerk, Automotive	10	10
835	Supply Clerk	9	11
667	Message Center Clerk	8	12
056	Postal Clerk	7	13
	Armament and Ordnance Group		
683	Bombsight Mechanic	29	1
678	Power Turret and Gunsight Mechanic	23	2
612	Airplane Armorer-Gunner	19	3
911	Airplane Armorer	17	4
511	Armorer	12	5
901	Munitions Worker	5	6
	Chemical Group		
870	Chemical Technician	27	1
809	Decontamination Equipment Operator	17	2
786	Toxic Gas Handler	13	3
	Airplane Maintenance Group		
750	Airplane Maintenance Technician	32	1
748	Airplane Mechanic-Gunner	23	2
685	Airplane Electrical Mechanic	21	3.5
686	Airplane Instrument Mechanic	21	3.5
684	Airplane Power Plant Mechanic	20	5
687	Airplane Propeller Mechanic	19	6.5
114	Machinist	19	6.5
665	Fuel Cell Repairman	18	8
528	Airplane Hydraulic Mechanic	17	9
747	Airplane and Engine Mechanic	16	10
555	Airplane Sheet Metal Worker	14	11.5
559	Glider Mechanic	14	11.5
550	Airplane Woodworker	12	13
548	Fabric and Dope Mechanic	10	14
689	Airplane Cable Mechanic	8	15.5
256	Welder, Combination	8	15.5
	Transportation Group		
014	Auto Equipment Mechanic	13	3
932	Special Vehicle Operator	8	2
931	Heavy Auto Equipment Operator	7	3
345	Auto Equipment Operator	6	4

time to time experienced difficulty in the reallocation of highly trained military specialists, especially when this reallocation necessitated the involvement of personnel at single, twin and four engine flying schools. It has been far too great a task to expect Headquarters Assignment Officers to analyze each enlisted man's qualifications to ascertain the type of equipment on which the individual has had training, thus earning a skilled or semi-skilled rating in a Military Occupational Specialty.

Such problems as "can an Airplane Maintenance Technician, experienced only on single engine, Basic Training planes, be adequately employed as an Airplane Maintenance Technician on four engine Flying Fortresses" are confronted daily by Personnel sections. Yet, objective answers to such problems are not to be found in existing Army directives. Further, the Engineering Officers at different airfields have been faced also with this perplexing problem, namely, that enlisted men qualified as Airplane Maintenance Technicians on Basic Training planes, were assigned to them for work as Airplane Maintenance Technicians, yet the airfield only has four engine planes stationed there. In the interest of good military classification, these enlisted men have earned their classification as Airplane Maintenance Technicians and should not be deprived of it. Yet in the interest of efficient engineering operations, the men are not qualified to perform the duties of a Maintenance Technician on, let's say, Liberator Bombers, B-24 planes. Personnel shortages at different airfields are rated only by the general Military Occupational Specialties without any specific reference to the type of equipment or airplane on which the men have had experience. Further, personnel are reallocated from airfield to airfield simply by mass numbers, disregarding, because of necessity, experience levels or types of experience of the individual man involved.

In order to overcome some of the personnel reallocation problems outlined above, it was decided that a comparison of indices for evaluated military specialties relative to single, twin and four engine airplanes be conducted. To compare adequately the total evaluated points assigned to each military specialty at single, twin and four engine flying schools, a job analysis was conducted, at representative stations of each of the aforementioned flying schools. Only those Airplane Maintenance Military Specialties performed at all three types of flying schools were subjected to the factor analysis breakdown. Comparative figures among the different types of single engine planes, as well as among the twin and four engine planes, proved to be insignificant. Therefore, the reallocation adjustment table (Table 4) has only three main groupings—single, twin and four engine.

Reasignment of surplus specialists or the reassignment of malassigned specialists, for corrective measures, between different types of flying

schools may be made efficiently if the relative evaluated job ratings at the different type of schools are made accessible to those in control of reassignment. For example, should an airplane Crew Chief on a Basic Training aircraft be sent to a four engine flying school if no vacancies

Table 4

Reallocation Adjustment Table

Single Engine		Twin Engine		Four Engine		
Suffix I		Suffix II		Suffix IV		
SSN	Job Title	SSN	Job Title	SSN	Job Title	Total Points
				750	AP Maint. Tech.	32
		750	AP Maint. Tech.			31
						32
						29
						28
750	AP Maint. Tech.					27
						26
						25
						24
						23
						22
		685	AP Elec. Mech.	686	AP Inst. Mech.	21
				685	AP Elec. Mech.	21
		686	AP Inst. Mech.			20
686	AP Inst. Mech.	687	AP Prop. Mech.	687	AP Prop. Mech.	19
687	AP Prop. Mech.					18
685	AP Elec. Mech.					18
		528	AP Hydraulic Mech.	528	AP Hydraulic Mech.	17
528	AP Hydraulic Mech.			747	AP and Eng. Mech.	16
		747	AP and Eng. Mech.			15
747	AP and Eng. Mech.	555	AP Sheet Metal Wkr.		AP Sheet Metal Wkr.	14
555	AP Sheet Metal Wkr.					14

exist at any other single engine schools? Reference to the Reallocation Adjustment Table presents the following picture:

a. Airplane Maint. Technician at a Single Engine School has been awarded 27 rated points.

b. Airplane Maint. Technician at a Four Engine School has been awarded 32 rated points.

From the standpoint of effective placement of personnel, a plus or minus (±) two (2) evaluated points is considered a reasonable difference to overcome, without losing too much training time, in the adjustment of

a specialist to a different type of job training. The adjustment problem involved here becomes, at once, apparent. This Airplane Maintenance Mechanic on the Single Engine plane would find it almost impossible to overcome the five (5) points difference were he to be placed on duty as an Airplane Maintenance Technician on a Four Engine plane. Thus, if he were transferred to a Four Engine Flying School, he would have to start in the lower category job, Airplane and Engine Mechanic (747).

Thus, it is apparent that reference must be made to the type of equipment upon which the enlisted man has won his rating as a Military Specialist and how the point value of that specialty at each type of Flying School compares before correct and efficient reallocation of military specialists can be effected.

Summary

In summarizing, the salient features of this job study have been:

1. The preparation of a standardized method to interpret the relative level of difficulty of different military jobs.

2. The preparation of point rating scale, with assigned values to each job, which is based upon nine significant job features. This helps reduce the subjective interpretation placed upon broad, generalized job specifications contained in the army publications.

3. The preparation of a reallocation table, applying the principles of factor analysis, to assist those military personnel people in the task of reallocating their overages and shortages of personnel most efficiently.

4. Although this job study was only utilized extensively in the Army Air Forces Eastern Flying Training Command, Headquarters, Army Air Forces, requested that distribution of "Job Evaluation for Army Military Occupational Specialties" be made for all Air Forces and Commands within the continental limits of the United States for their inspection and criticism. Reports received from these other Air Forces and Commands were most favorable and the general validity of the devised rating scale was not challenged.

5. The problem of military job classification, evaluation and personnel utilization is constantly assuming added significance. Perhaps some of the ideas set forth in this presentation will in some small way shed additional light upon these intricate problems.

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Aircraft Recognition: II. A Study of Prognostic Tests *

Lester Luborsky

Duke University

The present article reports an attempt to determine characteristics of the individual which influence his final level of performance in short-exposure aircraft recognition training. It was hoped that the approach followed would permit (*a*) the construction of a prognostic test battery, and (*b*) an analysis of the concomitants of the final level of performance. Because of the dearth of knowledge on this subject, the selection of factors to be studied was necessarily dictated by personal opinion as to the factors most likely to be involved, the possibilities of rapid measurement, and certain related aspects of importance in the life situation towards which the Navy recognition training program was directed. An instance of the last is speed of recognition.

The data in this paper were obtained during a previously reported experiment (2) in which 4 equated groups, totaling 30 subjects, were taught aircraft recognition in a standardized manner. The subjects were pre-aviation V-5 students at Duke University.

Before training, a battery of "pre-tests" was administered which was intended to (*a*) measure possible perceptual and learning factors associated with "aircraft recognition ability" and (*b*) aid in equating the groups. After training, an extensive battery of "post-tests" was administered to facilitate analysis of the final level of performance. It is the scores of all subjects on these pre- and post-tests and on the Final Test of aircraft recognition which comprise the main data of this paper.

In accomplishing the first aim, the selection of tests which have predictive value for the outcome of training, the procedure essentially was to correlate scores of all 30 subjects on the pre-tests with scores on the criterion test, in this case, the Final Test. The tests which correlated significantly were treated by the Doolittle technique to obtain the multiple correlation with the Final Test and the percentage of the variance accounted for by each test. A further subsidiary aim was to obtain at least suggestive evidence as to the concomitants of the final level of performance in aircraft recognition. This was based upon the intercorrela-

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tions of all tests, pre- and post-, and the necessarily subjective estimate of what each test tests. Because of the relatively apparent meaning of some of the tests, such as A. C. E. Psychological Examination and the Test of Previous Knowledge, and the large number of test intercorrelations, the task of interpretation was considerably facilitated.

Procedure

Classes were held for 45 minutes on Monday, Wednesday and Friday for a 6 week period. The pre-tests listed in Table 1 were administered

Table 1

Correlations of all Data with the Criterion
Pre 1, Pre 2, and Post Refer to the Time of Administration

*Span of Apprehension**		*Interest I*	.53
Pre 1	.13	*Interest II* (Improvement)	.47
Pre 2	.05	*Previous Knowledge of Planes*	
Post	.04	Pre 1	.41
Improvement Pre 1—Post	−.13	*Reaction Time*	
Improvement Pre 2—Post	.05	Light	
Memory Location		Pre 1	.02
Pre 1	.11	Post	.03
Pre 2	.10	Common Objects	
Post	.18	Pre 1	.18
Memory-Complex Figures, Part 1		Post	.41
Pre 1	.38	Improvement Pre 1—Post	−.06
Memory-Complex Figures, Part 2		Recognition of Planes	
Pre 1	.20	Post	.26
Memory-Airplane Recognition Aspects		*A.C.E. Psychological Examination*	.15
Pre 1	.29	*Grades in Academic Work*	.14
Post	.20	*Study Time on Aircraft Recognition*	
Memory-Complex Figures, 5"		*3rd Week*	−.57
Pre 1	.63	*Study Time on Aircraft Recognition*	
Acuity		*4th Week*	−.43
Pre 1	.03		
Post	.36		
Improvement Pre 1—Post	.54		

* Correlation coefficients after scoring by an alternative method (amt. ±) are: Pre 1 = .16; Pre 2 = .19, and Post = .06. The consistent lack of correlation is important because this test has been used in some recognition schools before training on the assumption that it improved aircraft recognition ability.

on two successive evenings 3 days before the training period began. The "Pre 1" tests were given on the first evening and the "Pre 2" tests, which were alternate forms of Pre 1 tests, were given on the second evening. The post-tests were on the Monday and Wednesday classes of the last week. These tests also were alternate forms with the exception of

Acuity and Recognition Time for Planes. In addition to the above, A. C. E. Psychological Examination scores and Grades in Academic Work were obtained from the Dean's office and Aircraft Recognition Study Time was obtained from a questionnaire on study habits.

The experimenter operated a Baloptican with a shutter attachment for obtaining 1/50″ to 1″ exposures (by calibration, 1/40″ and 4/5″ respectively). The stimulus figures were projected on a screen about 5 feet from the subjects. The testing was done in groups no larger than 8 to lessen the possibility of differences between subjects caused by seating position.[1] The less essential details of the apparatus and testing conditions are more fully described in another article (2).

Description of Tests [2]

1. *Span of Apprehension* (*Pre 1, Pre 2, Post*). The subjects were required to estimate the number of 5 centimeter [3] randomly arranged horizontal lines flashed on the screen for 1/50″. The projection area of the screen was approximately 15″ × 18″. Each test contained 16 exposures with 4, 6, 8, or 10 lines in each. The scoring was done in two ways: (*a*) the number of incorrect estimates, and (*b*) the sum of the deviations from the actual number of lines exposed.

2. *Memory-Location* (*Pre 1, Pre 2, Post*). A test of ability to reproduce on a grid sheet the location of a group of 3⅛″ × 5″ rectangles flashed on the screen for 1/50″. Each test contained 12 exposures of 5, 6, or 7 rectangles each. The score for each grid was the total of the omitted and incorrectly filled-in grid spaces.

3. *Memory-Complex Figures, Part 1, 1/50″* (*Pre 1*). Subjects must reproduce simple geometric line figures presented for 1/50″. Only 1 exposure was given for each of the 4 figures constituting the test. An arbitrarily-devised scoring system credited one point for each of 4 aspects of each figure.

4. *Memory-Complex Figures, Part 2, 1/50″* (*Pre 1*). Subjects must reproduce geometric line figures of greater complexity than in Part 1, presented for 1/50″. Each of 3 figures was given 4 times in succession and after each presentation the earlier reproductions were covered with the left hand while the new reproduction was drawn. The scoring was 1 point for each of 6 arbitrarily chosen aspects of each figure. The points for each reproduction were totaled to yield a score for each figure.

5. *Memory-Airplane Recognition Aspects, 1/50″* (*Pre 1, Post*). Plan view diagrams of airplanes, taken from *Aeronautics Aircraft Spotters' Handbook* (1) were presented for 1/50″. Sixty-five seconds were allowed after each exposure of a plane to check the presence or absence of 14 recognition aspects on a mimeographed check list. Subjects were informed that these were planes which were infrequently used and hence unfamiliar to them (as, e.g., Loire-Oliver 45, Falcho, Morane-Saunier 406). Before starting the test every effort was made to be sure that the recognition aspects in the check list were completely understood. To equalize the amount of guessing, subjects were directed

[1] Analysis showed no differences due to seating position. Staff, Psychological Test Film Unit (3), mention like conclusions.

[2] Fuller descriptions and illustrations of the test materials are presented in the doctoral dissertation available through the Duke University Library.

[3] Five centimeters after projection on the screen. The increase in size on projection is 1 to 5.

to leave no omissions. The Pre 1 test contained 10 planes, and Post test contained 5 additional planes.

6. *Memory-Complex Figures, 5″ (Pre 1, Pre 2).* This test is similar to the Memory for Designs test in the Stanford-Binet. The 2 cards in Pre 1 were almost identical with the test cards in Form L and M of the Stanford-Binet. Each test card contained 2 figures which were presented simultaneously for 5″. After approximately 3 seconds subjects were reminded to look at both figures. The figures on the Pre 2 cards [4] were considerably more complex than those of Pre 1. A more refined scoring than that used by the Stanford-Binet was devised—1 point for each of 5 aspects of the first figure and 1 point for each of 3 aspects in the second figure of *each* card.

7. *Acuity (Pre 1, Post).* This test employed the Snellen Symbol E Chart.[5] The subject indicated the direction of the open end of the E using two-eyed vision. The score was the number of E's correctly read, on a chart with 38 letters.

8. *Interest I,* and 9. *Interest II.* These tests were given at the end of the fourth week of training. By way of introduction, the experimenter stated that some planes would be described which would not be included in the course. However, students might be interested in these planes since they were commonly used in training aviation personnel and in passenger service. A test was given of 6 planes, 3 views for each, to see how many were already known before teaching. This test will be referred to as Interest I. The names, recognition features, and interest items for each plane were then discussed while viewing each plane for approximately 2 minutes each. Immediately after this teaching and without any previous warning another test was given to see how much had been learned. The Interest II scores are the improvement from the first to the second test. The scores on both the Interest I test and the Interest II test are considered as interest measures—the former on the assumption that those students interested in aviation would have known more of the common planes, and the latter on the assumption that those students with greater interest would be more receptive to the teaching.

10. *Previous Knowledge of Planes (Pre 1).* This test contained 33 of the 36 planes to be included in the syllabus, given a 3″ exposure for each. All were plan view diagrams.

11. *Reaction Time.* Before and after training, reaction times were taken for (*a*) seeing a 1/50″ light flash on the projection screen, and (*b*) naming common objects, such as umbrella, book, cat, etc., flashed on the projection screen for 1/50″. These two kinds of reaction time were expected to prove useful when the recognition time for planes, measured at the end of training, was to be interpreted. The subjects were required to lift their forefinger from a stimulus key in circuit with a standard timer to indicate recognition and then name the plane.[6]

12. *American Council on Education (A. C. E.) Psychological Examination.* Scores on this test (total score on linguistic and quantitative sections) were obtained from the Dean's office. Most of the tests had been administered during the previous semester.

13. *Grades in Academic Work.* The Dean's office also supplied the previous semester's grades in academic work. Scores are the average of point equivalents for each grade: 13 points for a grade of A, 10 for B, 7 for C, etc.

[4] It was found that this set of stimulus cards correlated highly with Pre 1 but with no other test. The greater complexity of these figures probably introduced an additional influence to that measured in Pre 1.

[5] American Optical Co., No. 1942.

[6] The writer is indebted to Mr. Walter Knight of the Department of Physics, Duke University, for constructing the efficient reaction time shutter attachment.

14. *Study Time on Aircraft Recognition, 3rd Week.*
15. *Study Time on Aircraft Recognition, 4th Week.* The time spent in studying aircraft recognition outside of class was recorded on a questionnaire on study habits. The total time in minutes for each week was used for correlation purposes.

The Criterion Measure: the Final Test

All tests were correlated with the 1/50″ Final Test which was administered at the eighteenth session, the last session of the course. In the last 2 weeks of this course all groups were trained at the 1/50″ standard and given many views of each plane. One picture and one diagram view of all 36 planes taught gave a total of 72 exposures in the 1/50″ Final Test. This test was longer and more difficult than any previously given. The split-half reliability coefficient was +.77.

Results and Discussion

Tests with Significant Correlations with the Final Test and with Each Other. The correlation coefficients of all tests with the criterion are presented in Table 1. Table 2 presents only those pre-tests with signifi-

Table 2

Main Tests: Correlation with Criterion, Reliability, and Significant Correlations with Other Tests

	r with Final Test	Reliability: Self-*r* or Test-retest	Significant *r*'s with Other Tests	
1. Memory-Complex Figures, Part 1, 1/50″	.38	Part 1 / Part 2 .43	Memory-Complex Figures, 5″	.36
2. Memory-Complex Figures, 5″	.63	Pre 1 / Pre 2 .74	Memory-Location, Pre 2	.54
			A.C.E. Psychological Examination	.43
			Memory-Complex Figures, Part I	.36
3. Previous Knowledge of Planes used in the Syllabus	.41	.74	Interest I	.43
4. Interest I	.53	.42	Previous Knowledge	.43
5. Interest II	.47	—*	A.C.E. Psychological Examination	.64

* No satisfactory method is available for finding the reliability of this improvement score. However, an improvement score cannot be reliable if the tests from which it is calculated are unreliable. The split-half reliability of the test from which Interest II is derived are .42 and .52 respectively.

cant [7] correlations and also includes their reliability coefficients and a list of other pre- and post-tests with which these correlate significantly. The highest correlations with the criterion [8] (Table II) are (1) Memory-Complex Figures, Part 1; (2) Memory-Complex Figures, 5″; (3) Previous Knowledge of Planes used in the Syllabus; (4) Interest I, Knowledge of Planes (trainers and passenger); (5) Interest II, Improvement in Knowledge of Planes (the same planes as in Interest I). The significant correlations of these "main" tests with other tests should give some hints as to the nature of these main tests and at the same time a better understanding of the nature of "aircraft recognition ability." This problem will be more profitably considered after arriving at an estimate of the variance contributed by each main test to the total variance.

Development of a Prognostic Test Battery. In the development of a prognostic test battery, the intercorrelations of 5 main tests and the Final Test were treated by the Doolittle technique and a multiple correlation (R) of .855 obtained. The index of forecasting efficiency is 48.2%. The standard error of estimate was found to be 4.09. This means that in 67% of cases the predicted criterion score will be within 4.09 points of the actual criterion score. The R has a coefficient of multiple determination of approximately 73% of the variance in the Final Test. Each variable contributes the following amount to the total variance: X_2, Memory-Complex Figures, Part 1, 1/50″, 8.0%; X_3, Memory-Complex Figures, 5″, 28.9%; X_4, Previous Knowledge of Planes, 9.5%; X_5, Interest I, Knowledge of Planes, 13.0%; and X_6, Interest II, Improvement in Knowledge of Planes, 13.6%. By far the greatest contribution is made by Memory-Complex Figures, 5″. Interest I had Interest II make the next greatest contributions. However, all contributions are large enough to make it desirable to use all tests if this battery were to be used prognostically.

Beta weights were then computed and the following regression equation for predicting the criterion scores from the 5 tests was found: $X_{1\,\text{Pred.}} = -3.100 + 1.033\ X_2 + 1.815\ X_3 + 0.443\ X_4 + 0.576\ X_5 + 0.117\ X_6$.

It was suggested above that all of the tests should be used for prognosis since none of the variance contributions is small enough to disregard.

[7] All correlations must be .36 to be significant at the 5% level and .46 to be significant at the 1% level.

[8] Since the highest obtained correlation coefficient between consecutive aircraft recognition tests is only .64, a correction for attenuation would considerably increase all correlations. However, it was thought more desirable in this preliminary study to present all the coefficients exactly as obtained and merely note the fact that a correction for attenuation would have the effect of increasing all coefficients by $1/\sqrt{.644}$ or e.g. if $r = .38$, $r_c = .48$.

Use of all tests presents no administrative difficulties, since all tests would take less than 45 minutes.[9] However, after this battery is validated on another new and larger group, it may be found that inclusion of some of the tests is not economical. Furthermore, it is likely that lengthening of certain of the tests will result in an even greater R. The high R already obtained indicates that the preliminary search for prognostic tests appears to have succeeded in sampling the major areas contributing to success in aircraft recognition training.

Table 3

Diagrammatic Analysis of Interrelationships (Significant Correlations) Between the Main Tests;* Final Test and the Main Tests; and the Main Tests and Other Tests

Kind of Factor	Main Tests (Correlated Significantly with Final Test)	Tests Correlated Significantly with Main Test but not with Final Test
	Measured before Training:	
Memory	Memory-Complex Figures, Part 1, 1/50″	
	Memory-Complex Figures, 5″	Memory-Location
		A.C.E.
Past Knowledge	Previous Knowledge of Planes	
	Interest I	
Interest	Interest II	A.C.E.
	Measured after Training:	
Acuity Improv.	Improv. in Acuity	
Reaction Time	Reaction Time: Common Objects (Post)	Reaction Time: Recognition of Planes (Post)
Study	Study Time for Aircraft Recognition**	

* Main tests which are significantly correlated are bracketed.

** A negative correlation.

Analysis of Conditions Influencing Performance. One aim of this experiment was to obtain at least suggestive evidence which would increase understanding of the concomitants of successful performance. The variance contribution of each pre-test to the total variance is presented in the preceding section. In the present section a more complete analysis will be attempted. For this purpose all tests, rather than only the pre-tests, with significant correlations with the criterion, must be

[9] Administrative time required for each test: X_2 = five minutes; X_3 = five minutes; X_4 = ten minutes; X_5 = five minutes; and X_6 = twenty minutes. Total administration time = forty-five minutes.

considered. In addition, these tests might be better understood by considering the tests with which they, in turn, correlate significantly. The diagrammatic analysis in Table 3 is based upon both sets of correlations.

A hypothetical analysis of the concomitants of successful performance based upon Table 3 might be as follows:

(*a*) Memory for complex figures, perhaps of a visual memory type. Both memory at 5″ and 1/50″ exposure are involved but particularly the former.

(*b*) Past interest in learning planes and resultant knowledge of some planes.

(*c*) Interest and intelligence [10] which permits ready learning of planes.

(*d*) A tendency to adapt to the visual conditions demanded by the mode of presentation of planes. This is an inference from the significant correlation of Improvement in Acuity and the Final Test.

(*e*) After training there is ability to recognize and name common objects more quickly under short exposure presentation conditions.

(*f*) Existence of the above make a great deal of studying unnecessary. Another possible interpretation is that much study of the kind done actually interfers with proper learning.

It is possible to infer from the variance contributions previously determined that the first 3 concomitants listed above are important for successful performance in the order listed. The factor which contributes the most to the final level of performance is the ability to remember complex material, relatively independently of exposure time. The past knowledge factor which contributes the second largest amount may also be considered a memory factor.

Summary and Conclusions

The data for the present report were obtained almost entirely from tests given before and after an aircraft recognition training course. A prognostic battery and regression equation were found by applying the Doolittle technique to pre-tests with significant correlations with the Final Test. All of these selected pre-tests were found to contribute sufficiently to the total variance to warrant inclusion in the prognostic battery. Because of the high multiple correlation of .85 and the ease of administration of these tests, validation of the battery on a new and larger group of students is recommended.

[10] Although the intelligence measure (A. C. E.) did not correlate significantly with the Final Test, it did correlate highly with Interest II.

On the basis of the significant correlations between individual tests and the criterion, a hypothetical analysis was attempted on the concomitants of achieving successful performance in recognition under conditions of short exposure. These concomitants are briefly as follows: (*a*) memory for figures; (*b*) previous knowledge of planes; (*c*) interest and ability in learning planes; (*d*) adapting to the short exposure visual conditions; (*e*) quick recognition of common objects after short exposure training; and (*f*) comparatively less home study.

These relationships should hold particularly for recognition of this specific stimulus material. However, there is good reason for supposing that the relationships would hold for recognition of material of comparable level of complexity and of similarity within the group of items.

Furthermore, the data presented in this section are of great utility for future experiments. The analysis of concomitants of achieving the final level of performance would enable a more complete equation of groups than was possible before this experiment, and would open the way to final answers to the kinds of problems described in an earlier experiment (2) on the relative efficiency of training procedures.

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Psychological Principles in Army Administration

Louis L. McQuitty,* Lt. Col., AGD

University Training Command, MTOUSA, APO 49, c/o Postmaster, New York, N. Y.

The army encompasses a tremendous administrative responsibility. This is true both from the point of view of the number of individuals administered and from the many details of human behavior minutely affected. Some military psychologists have proven so successful in their approaches to administrative problems that their commanders have placed them in larger administrative duties involving fascinating and practical psychological problems. Most of the psychological problems posed cannot be referred for final solutions to established laws, principles or axioms. An alternative approach is to obtain as much insight as possible through discussions by those trained in fields of knowledge closely related to the problems. This paper represents one such discussion. It outlines tried methods of solutions to army administrative problems and suggests the psychological principles from which they appear to derive.

Administrative Organization

One of the first problems containing psychological implications with which the army administrator must concern himself is the type of personnel organization he is going to install in order to accomplish the mission for which he is responsible. The size of the mission is often so great that the administrator cannot accomplish the job by himself and cannot even keep himself informed on all of its many aspects. It is therefore incumbent on the administrator that he divide the mission into goals and assign the goals to sub-administrators.

The division into goals should be based on a careful study of the mission. The mission requires execution of certain work functions in order to accomplish it. These work functions form clusters in the sense that the component functions of any one cluster are highly dependent upon one another but are relatively independent of the functions of other clusters. The division of the mission into goals should be so accomplished that each goal represents a cluster of work functions. An illustration of

* On military leave of absence from the Department of Psychology, University of Illinois.

this point is readily available in the consideration of personnel administration and classification responsibilities as a mission. One possible division would be to have a personnel administration section and a classification section. Each section would handle its particular responsibilities as they pertained to both officers and enlisted men. An alternative division would be to have an officer section and an enlisted section. Each section would handle personnel administration and classification functions, one section as they pertain to officers and the other as they pertain to enlisted men. A comparative study of these two alternative divisions reveals that soldiers on duty in the officer section could operate satisfactorily with little reference to soldiers on duty in the enlisted section. The work functions represented by the officer and enlisted sections constitute clusters and the clusters are relatively independent. This condition is just the opposite of that which exists when the division is into a personnel administration section and a classification section. The soldiers on duty in these two sections must be continually communicating with one another in order to function satisfactorily. These two sections do not represent independent clusters.

The division of the mission into goals represented by relatively independent work clusters, as purposed herein, is considered to be desirable because of the following reasons:

(1) It minimizes the amount of coordination needed; (2) It lessens the chances for personality frictions which are apt to occur when persons of equivalent rank and responsibilities have to coordinate and determine for which aspect of a mission they are responsible; and (3) Each sub-administrator has the maximum amount of autonomy possible within army organization. Practically all his dealings are with his immediate superior or his immediate subordinates.

The administrator, unless he is charged with a small and minor mission, will find it advisable to delegate to sub-administrators all of the duties contained in the mission. This will leave the administrator free to discharge the responsibilities of general supervision, coordination with those on an equivalent administrative level, and to report to and receive directives from his immediate superior. General supervision should include: (1) A review of non-routine work submitted to higher authority; (2) A review of the assignments of incoming non-routine tasks to sub-administrators in order to assure that the original division into sub-missions is followed or revised when appropriate; (3) A continual review of personnel allotments to the sub-divisions in order to maintain equivalent work loads for all concerned as the amount of work charged to the sub-divisions fluctuates; and (4) Inspections of the accomplishments of sub-administrators.

If the administrator follows this plan of office organization, he will usually discover that from four to six is the appropriate number of sub-administrators for his immediate supervision.

Having attempted to so organize the functional aspects of the office to assure wholesome relationships between personalities, the administrator can further the realization of the desired ends by an appropriate distribution of office space. This statement is based on the assumption that desired cooperation is more likely to ensue if it is made easy, the parties concerned are friends, and each appreciates the problems of the others. It is believed that these latter conditions are usually achieved if the sub-administrators are placed in the same office or in adjoining offices and communication between them is readily available at all times.

It is felt that the above suggested organization tends to facilitate smooth operation because it decreases the chances for personality frictions by lessening the possibilities for misunderstandings and frustrations. It charges the administrator primarily with the job of making the organization function properly. This enables him to forsee possible personality difficulties before they arise and to act to correct them before they become serious.

Having organized the office, both from the point of view of space assignments and functional responsibilities, there are the problems of the relationships of the administrator to his sub-administrators, to his co-administrators and to his superior.

Relationships between Administrator and Superior

The significance of the relationship of the administrator to his superior is realized in part when one recalls that in army life a soldier is responsible to his superior for practically everything he does or fails to do. It is therefore incumbent upon a soldier administrator to build a wholesome relationship between himself and his superior. In order to achieve this end he should learn the details of his superior's personality. He should listen very attentively to everything he says. He should study his motivations and attempt to predict his reactions to situations as they arise. He should put tactful questions when answers to these assist him to know better the desires of his superior as they pertain to military matters and when the questions can be put without arousing offense. These suggestions derive from the principle that there are wide individual differences in superiors and what might appeal to one would be acted on unfavorably by another. The solution is to know the superior to whom one is responsible as well as possible so that appropriate matters may be presented in a manner so as to be favorably received.

Despite the individual differences in superiors there are usually some principles of approach that will be favorably received by most of them.

It is well to be acquainted with these because in army life there is often a change in the individual to whom any one is responsible, and the generally acceptable principles have to be relied upon until one can learn the personality characteristics of his new superior. One can try the generally applicable principles and observe closely their effects. He can revise them in the light of his observations.

Primary among the generally acceptable principles is the desirability of putting one's suggestions for the accomplishment of tasks or goals too his superior in such a way that they imply that the administrator fully realizes that decisions on the matters are the prerogative of the superior. If any of the suggestions are adopted and prove successful, the administrator can usually motivate wholesome relationships, if he makes inherent in his report of the success to the superior the realization that it was the judgment of the superior which decided in advance that the ideas would be successful. This tends to encourage in the superior the feeling of ownership for the program involved and thus the program obtains his support more effectively. Several repetitions of this nature create in the superior more and more of a feeling of personal ownership for all of the programs that derive from the administrator under consideration to the end that the latter obtains a very high level of support.

On the other hand, if an idea suggested by the administrator and approved by the superior should fail, it is well that the report of failure include the realization by the administrator that he suggested the idea and accepts responsibility for its failure. The necessary derogatory impression ensuing from a report of failure is lessened by including a suggestion—particularly well thought out—to improve or substitute for the idea which failed on first trial.

Many of the suggestions which the administrator recommends to his superior will originate with his immediate sub-administrators or even lower in the administrative echelon. It is well that the administrator credit them to the appropriate individuals when he recommends them to his superior because this is one way in which the administrator can encourage his superior to the realization that his actions are not predicated on a mere desire to create a particularly favorable personal impression. In addition, to give the credit where due will help one's relationship with one's sub-administrators because the chances are the superior will acknowledge the contribution at some time to the sub-administrators concerned, and the sub-administrators will feel kindly to know that they have been given due credit.

At times the administrator will receive from his superior directives with which he may immediately disagree. It is wise that he be hesitant about expressing his disagreement unless invited to do so, and then it

should be done with reservations. It may be that the superior, and even his superiors, have spent a great deal of time thinking through and studying the directives. The directives may be the product of tremendous efforts. For the administrator, a junior, to object with little apparent study may not portray due respect and may be unfavorably received because of the apparent failure of the administrator to give due study to the directives before voicing his attitude toward them. Also if he takes time for himself and his sub-administrators to study them and report to him he may arrive at more valuable conclusions, which will be more respected because they have first been given due consideration, and the superior may not be as emotionally interested in the directives as he was soon after he may have spent hours working on them and thinking about them. Also the administrator establishes an attitude of confidence toward himself if he is very cautious about raising problems in connection with directives to him. He may be able to establish in his superior the attitude that the latter should consider very carefully when the administrator raises a problem. Such, of course, would be a definite asset to the administrator and would probably spread to become a more general attitude of regard by the superior toward the administrator.

Another possible way to build a favorable attitude in the mind of the superior and to save him embarrassment as well as put him in a position to justly defend the actions of his subordinates is for the administrator to keep the superior especially well informed on what transpires. This applies in particular when the administrator or his staff has been guilty of an oversight or some other type of negligence or when occasion has required the issuance to commanders of lower echelons directives to which they are expected to object. The chances are the negligence or objection will be reported through command channels and will come to the superior from personnel to which he is responsible. He can do much to retain cooperation and understanding among all concerned if he is in a position to give immediately the full story on the matter under consideration.

There is of course always a question of the minuteness of matters of potential objection and negligence which should be reported to the superior by the administrator. The answer to this problem depends on the personal preference of the superior and can usually be discovered by appropriate questioning when such matters are reported. His preference will usually reflect the attitude of the individuals to whom he is responsible and the tendencies of lower and higher commanders in reporting objectionable matters. Some commanders will attempt to report their objections with reasons to the office which issued the directive involved and which appears to be immediately responsible so that a more satis-

factory arrangement may be evolved at that level if possible. Others will invariably report their objections to personnel in higher echelons of administration and therefore make it desirable for those personnel to keep well informed on the matters because they can thereby make a more favorable impression on the objecting commander, who usually ranks the administrative personnel, to the end that cooperative understanding has a better chance of continuing.

The points just outlined covering principles that are considered generally helpful to an administrator in adapting to his superior are predicated on the belief that personal understanding between the two concerned is of primary importance, that the administrator as the junior should consider it his responsibility to make whatever adaptation is necessary to accomplish the desired relationship, that the administrator should regard himself as an assistant to the superior in the accomplishment of the latter's mission, that frankness and cooperation are essential to personal understanding, and that credit will accrue to those to whom it is due much more readily if they make no obvious moves designed merely to enchance it—and besides—self credit, especially in a war effort, is of no consequence; the one great dedication should be successful and efficient prosecution of the war.

Relationships between Administrator and Sub-Administrators

The fundamental fact to keep in mind in considering the relationships of the administrator to his sub-administrators is that the discussion is here pitched at that echelon where the size of the mission is so large that its accomplishment has been entirely delegated—leaving the administrator free to give his full time to the supervision of his subordinates. The administrator is dependent upon his subordinates for accomplishment of the mission, and his success depends on his qualities of leadership in a particular field. His job is to assure that the maximum achievements are realized by his subordinates. These achievements must be realized as a functional component of a much larger whole. They must be appropriately adjusted to the much larger functional framework. The administrator must therefore be a successful teacher. He must be able to give his sub-administrators a clear concise picture of the mission for which he is responsible. He must be able to give a significant and meaningful picture of how this mission fits into the larger framework. He must be able to teach each sub-administrator to realize and comprehend his particular goal in its perspective to the goals of other sub-administrators and in perspective to the still larger functional framework. He can test his success. If his subordinates are making recommendations which his knowledge of the overall situation frequently reveals to him are inappropriate, then he is not keeping his subordinates sufficiently well in-

formed—and if he is passing these recommendations on approved to higher administrative echelons where they are not favorably considered, then he is not keeping himself nor his subordinates sufficiently well informed. The suggestions just offered are believed to derive from the principle that appropriate achievements depend on clear cut understandings of missions and that one characteristic of respected leadership depends on an unbiased ability to search oneself and one's organization for shortcomings before blaming one's subordinates.

If the shortcomings are discovered in oneself, one must take immediate steps to correct them, and one way that one can usually assure himself that he and his subordinates are sufficiently well informed to properly discharge their duties is to attempt to keep himself sufficiently well informed to accomplish the mission of his superior and frankly attempt to keep his immediate subordinates sufficiently well informed that any one of them could step into his position. This has the effect of keeping a personal goal immediately in front of all personnel concerned and acts as a strong motivating factor. It also makes a very favorable impression on superiors to observe the continued smooth functioning that ensues even though key personnel are suddenly lost as so frequently happens in many army organizations.

The above suggestions encourage successful leadership through careful instructions to subordinates. Another method of giving direction to the work of subordinate is for the administrator as the leader to assist his subordinates to know his personality characteristics. The better able he is to acquaint them with his personality characteristics the better able they will be to follow his desires. He will assist his subordinates in this respect if he always gives reasons for his decisions. In addition, this policy makes him very careful of his decisions and often prevents him from making errors of decision, especially so, if he creates in his subordinates a feeling of freedom to express disagreements. This feeling is enhanced if such expressions are always given careful and tactful consideration and if appreciation is shown for them even though they are not accepted. The approach just offered is believed to derive from the principle that freedom of action—herein fostered by an overall knowledge of the mission plus responsibility for definite goals—encourages initiative.

Initiative can often be still further encouraged by emphasizing responsibility to personnel to whom goals are assigned. Such personnel will sometimes come to the administrator with questions designed to obtain the solution from him—and for the administrator to give it will encourage dependence upon him at the expense of properly developing his subordinates.

The assignment of goals also obligates the administrator from the point of view of some subordinates. They feel that the administrator

should at least give them an opportunity to express their opinions on matters prior to a decision having been made. To comply with this obligation should not only assist in developing and maintaining desired personal relationships but should also produce valuable ideas which might otherwise be overlooked.

The suggestions enumerated above are based on the principle that smoother personal relationships are maintained and more is achieved when all personnel are given a clear cut understanding of their responsibilities, are taught to exercise their initiative, and the initiative of all is given proper direction by means of keeping all personnel sufficiently well informed so that they have proper perspectives for expressing themselves.

Relationships between Administrator and Co-Administrators

By keeping oneself especially well informed and by thinking out ones decisions with ones sub-administrators, as just outlined, the administrator keeps himself peculiarly adept to deal effectively with his co-administrators, with whom he must cooperate and with whom he is often in competition. He must cooperate with them because all are working for the accomplishment of the mission of their common superior and for the greater goal of successful and efficient prosecution of the war. He is often in competition with them because all are often highly motivated by the superior, all are rated as to efficiencies by their superior, and disagreements arise as to how the mission of the superior should be accomplished and as to whom of the sub-administrators should be responsible for the various aspects of the mission. The administrator who is well reinforced by knowledge and carefully thought out principles has the advantage because he is prepared for discussion periods which usually arise suddenly. In alternative solutions that arise in these discussions he should take only efficient accomplishment of the mission of his superior as the primary purpose, and this principle in conjunction with an unusual background of pertinent knowledge will give him a solution for which he can acquire support through an intellectual, non-emotional, presentation. This presentation will encourage better personal relationships if the intellectual contributions are offered in the form of suggestions and if the contributor takes advantage of every opportunity to evolve them from the personnel in the discussion. He will then usually be admired by his colleagues and appreciated by his superior.

The proposals herein offered for efficient functioning of an administrative organization are analogous to those often proposed for the healthy minded functioning of a human organism. They derive from the primary principle that efficiency will ensue in the organization, or organism, if there is a clear cut goal adjusted to the capacity present and if all components are carefully directed and motivated toward its realization.

Resumé and Psychological Possibilities

This paper was motivated by the realization that never before have psychologists contributed so much in so many assignments heretofore not filled by personnel especially trained in the understanding of behavior. The exigencies of war and the success of some military psychologists in non-specialized aspects of their assignments have placed them in these pursuits. This unusual situation demands discussion in order that it may be properly evaluated, in order that full advantage may be taken of its opportunities, and—more specifically—in order that psychologists in these assignments may take advantage of the contributions of their colleagues.

The paper outlines psychological approaches that have been applied to certain army administrative problems. The discussion is pitched at that level where the administrator must depend entirely on his subordinates for the accomplishment of the tasks. His achievement depends on leadership and organization. He teaches his subordinates to understand clearly their goals in proper perspective to the larger missions. He encourages and developes responsibility, initiative and determination in his subordinates and gives them the maximum authority justified by their understanding of the missions. He establishes an organization which facilitates wholesome personal relationships and which minimizes the amount of coordination required. He motivates maximum effort and directs it into the channels where it is most productive.

It is hoped that this paper will encourage other similar discussions. It may be that these discussions would reveal many psychological approaches which could be applied to practical pursuits of peace time living. It may be that material could be gleaned for psychological courses in business administration and other practical subjects. It may be that many psychologists have been developed into practical administrators and executives capable of outstripping their non-specialized competitors. And, it may be that many occupational pursuits, now considered non-professional, involve so many psychological considerations that they could be more effectively discharged by personnel specialized in the understanding of human behavior.

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A Statistical Study of Visual Functions and Industrial Safety

N. Frank Stump

General Personnel Department, Revere Copper and Brass Incorporated, Rome, New York

The purpose of this study was to determine the statistical significance of differences between average visual performance for various accident groups. Three groups evaluated from first aid records were compared: (1) An Accident-Free group, (2) A High-Frequency-of-Minor-Accident group, and (3) A Serious-Injury group. The employees were classified in each of these groups by the Safety Engineer, a Personnel Assistant, and the Author, after thoroughly examining the individual accident records for a twelve-month period.

Visual Tests Used

Twelve visual tests were administered to the three employee groups having various past histories regarding accidents. The complete set of tests are incorporated in the Bausch and Lomb *Ortho-Rater*.[1] They are:

1. Acuity, both eyes, far and near distances; 2. Acuity, each eye separately, at far and near distances (not occluded); 3. Vertical and Lateral Phoria,[2] or Muscle Balance, at far and near distances; 4. Color; and 5. Depth or Stereopsis.

Since the tests for "Acuity, each eye separately" were administered without occlusion, both eyes were functioning normally, even though each was being tested separately. The natural-function method is far superior to the obsolete procedure of placing a cardboard before alternate eyes when testing. Unfortunately, this latter method is being generally used today for certifying auto drivers throughout the country, and for testing industrial employees during medical examination.

Results

Table 1 shows Means and Critical Ratios for 22 visual test scores including various score combinations. If raw scores from only twelve Ortho-Rater tests were considered, the number of comparisons between visual functions would have been limited. By combining these raw

[1] For description of these tests see: *Standard Practice in the Administration of the Bausch & Lomb Occupational Vision Tests with the Ortho-Rater*, February, 1944.

[2] Joseph Tiffin, *Industrial psychology*. New York: Prentice-Hall, Inc., 1942. Ch. VI.

Table 1

Means and Critical Ratios of Three Accident Groups Compared with Regard to Various Visual Functions

(Note: A = Accident-Free; B = High-Frequency; C = Serious-Injury. N = 108.)

Tests	Means			Critical Ratios		
	A	B	C	M_A–M_C	M_A–M_B	M_B–M_C
1. Acuity—Both Eyes—Far	10.81	10.14	9.83	2.23	1.69	.65
2. Acuity—Right Eye—Far	9.89	8.83	8.86	2.13	2.26	.05[1]
3. Acuity—Left Eye—Far	9.86	8.67	8.61	2.06	2.08	.08
4. Acuity—Better Eye—Far	10.53	9.72	9.69	2.03	2.21	.06
5. Acuity—Worse Eye—Far	9.25	7.78	7.78	2.53	2.56	.00
6. Lateral Phoria—Far	7.44	6.72	7.19	.37	1.25	.67[2]
7. Vertical Phoria—Far	5.56	5.25	4.92	1.75	1.02	.80
8. Acuity—Both Eyes—Near	11.08	10.69	10.58	.98	.87	.21
9. Acuity—Right Eye—Near	9.03	8.58	8.92	.18	.70	.50[3]
10. Acuity—Left Eye—Near	9.61	9.28	9.06	.92	.57	.33
11. Lateral Phoria—Near	6.33	7.14	7.31	1.23[4]	1.02[5]	.21[6]
12. Vertical Phoria—Near	4.61	4.61	4.00	1.84	.00	1.50
13. Lateral Phoria—Near subtracted from Far, plus 10	11.11	9.58	9.89	1.77	1.99	.39[7]
14. Better Eye—Near subtracted from Far, plus 5	5.53	4.64	4.89	1.09	1.63	.50[8]
15. Worse Eye—Near subtracted from Far, plus 6	6.61	5.97	5.58	1.84	1.04	.72
16. Worse Eye—Near	8.64	7.86	8.17	.77	1.24	.44[9]
17. Better Eye—Near	10.00	10.03	9.81	.36	.05[10]	.40
18. Depth	5.64	3.53	4.72	1.31	3.27	1.60[11]
19. Color	4.44	4.25	4.31	.44	.60	.17[12]
20. Vertical Phoria—Near subtracted from Far, plus 3	3.89	3.64	3.92	.08[13]	.90	.78[14]
21. Acuity—Both Eyes—Near subtracted from Far, plus 5	4.72	4.44	4.25	.82	.57	.39
22. Total for 7 tests—Both; Right; Left; Better; Worse; (Far Vision) Lat. Phoria, Near from Far; and Depth	67.08	58.25	59.39	2.69	5.44	.44[15]
23. Education—Grades completed in school	8.53	9.00	8.56	.05[16]	.90[17]	.82

Explanation of footnote numbers: The following combinations should read M_C–M_A 4, 13, 16; M_B–M_A 5, 10, 17; and M_C–M_B 1, 2, 3, 6, 7, 8, 9, 11, 12, 14, 15.

scores into different combinations, however, a total of 22 actual and alloyed values resulted.

Educational Status of the Three Groups Compared

The number of school grades completed was taken as an indication of the mental alertness of the individuals. Some studies have been made

which indicate that the amount of schooling received is a fair index of general ability. It was regarded, therefore, as essential to hold education fairly constant, on the average, for the three groups. The Critical Ratios between the three injury groups indicate that the average differences in schooling received by these groups are not significant,[3] the Critical Ratios for the Accident-Free group as compared with the High-Frequency and the Serious-Injury group being .90 and .05, respectively. The Critical Ratio of the High-Frequency group when compared to Serious-Injury group was .82.

Accident-Free vs. Serious-Injury

The data reveal that the Ortho-Rater Means show a significant difference in favor of the Accident-Free group over the Serious-Injury group in the following visual functions: (*a*) Acuity—both eyes, far vision; (*b*) Acuity—right eye, far vision; (*c*) Acuity—left eye, far; (*d*) Acuity—better eye, far; and (*e*) Acuity—worse eye, far.

When seven of the visual tests in the Ortho-Rater were combined a highly significant difference resulted between the Mean scores of Accident-Free employees and Serious-Injury scores, the Critical Ratio being 2.69.

Accident-Free vs. High-Frequency

Critical ratios exceeded the criterion when the Accident-Free group was compared with the High-Frequency group on the following test data: (*a*) Acuity—right eye, far; (*b*) Acuity—left eye, far; (*c*) Acuity—better eye, far; (*d*) Acuity—worse eye, far; and (*e*) Depth.

Special mention should be made of the Critical Ratio of 1.99 of Lateral Phoria,—near subtracted from far. Since this Critical Ratio is only .04 below the criterion, a definite trend is unquestionably indicated here.

The combined total of seven visual tests indicates a highly significant difference between the Mean scores of the Accident-Free and of the High-Frequency group, the Critical Ratio being 5.44.

High-Frequency vs. Serious-Injury

Not a single Critical Ratio meets the criterion (2.03) for significant difference between these two groups. These findings are what one should naturally expect, provided the personnel for these experimental groups were properly evaluated. It is generally agreed among authorities in the field that a High-Frequency case is a potentially Serious-Accident case; so, the *present* Serious-Accident individual is, in many cases, the *previous* High-Frequency individual. This thesis is important in the prediction

[3] J. P. Guilford, *Psychometric methods.* New York: McGraw-Hill Book Company, Inc., 1936, 548–549. A value of 2.03 is the criterion selected for significance.

of the eventual Serious-Injury individual on the basis of High-Frequency. This fact is further substantiated by the low Critical Ratio, when a composite of seven visual scores was studied between the High-Frequency and Serious-Injury group.

Of course, there are some exceptions to the rule. There may be some persons who have serious accidents but who never have been classified as the High-Frequency type. Nevertheless, these data support the above thesis quite well.

Visual functions seem to be an important contributing factor for the safety of the industrial worker. Obviously, many factors enter to make an employee an absolutely safe worker, but visual functions have only recently taken their place as being equally as important as, if not more important than, other factors covered in the literature on safety.

Summary

(1) The Accident-Free group is significantly superior in visual functions to the Serious-Injury group and also to the High-Frequency group in the following: (*a*) Acuity—right eye—far vision; (*b*) Acuity—left eye—far vision; (*c*) Acuity—better eye—far; and (*d*) Acuity—worse eye—far.

This points to conclusions similar to those reached in previous experiments reported by the writer.[4] It is well to note that the Accident-Free group earned significantly higher scores in visual performance for the poorer eye than did the other two groups.

(2) Acuity, Both Eyes, Far Vision scores indicate the Accident-Free group to be superior to the Serious-Accident group.

(3) Depth perception is present to a significantly higher degree in the Accident-Free group than in the High-Frequency group.

(4) In addition, there seems to be a trend in the direction of the visual functions and safety; Lateral Phoria—Near subtracted from Lateral Phoria—Far.

(5) When a composite of seven visual functions was made the Accident-Free group was superior to the High-Frequency and Serious-Injury group, the Critical Ratios being 2.69 and 5.44, respectively.

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[4] Visual functions as related to accident-proneness. *Personnel*, 1944, **21**, 50–56; Spotting the accident-prone workers by visual tests. *Fact. Mgmt.*, 1945, **103**, 109–112; Visual functions and safety. *Nat. Safety News*, 1944, **49**, 22 ff.

Effect of Visual Adaptation Upon Intensity of Illumination Preferred for Reading With Direct Lighting *

Miles A. Tinker

University of Minnesota

A reader rarely hesitates to express a preference for what he considers to be an adequate light intensity for easy and comfortable reading. Luckiesh and Moss (4) claim that this subjective method of investigation yields both significant and interesting results. Although they admit that such results are not desirable for laying a scientific foundation for lighting, it is employed by them as corroborative evidence. In general, preferences for illumination intensities have been employed for two purposes: (1) as supplementary data in prescribing foot-candle standards for reading and (2) to persuade consumers that a high level of light intensity is desirable. The validity of such practices may be questioned. In this paper the plan is to examine critically the evidence in the field and to present new experimental data on the validity of preferred intensities as a measure of ease of seeing.

Review of Previous Experiments

In a study by Luckiesh and Moss (4), 82 subjects selected the intensity of illumination considered as ideal for an extended period of reading black print on white paper. The readers employed their own criteria of comfort afforded by the lighting. Intensities from 10 to 1,000 foot-candles were available. Preferences were distributed as follows: 11 per cent at 10 foot-candles, 18 at 20, 32 at 50, 20 at 100, 17 at 200, 1 at 500 and 1 at 1,000. Although it is stated that the subjects chose an average of about 100 foot-candles, the authors do not note that the median was at 50 in this atypical distribution. It is common statistical practice, of course, to use the median rather than the mean in atypical distributions. In another report (1) Luckiesh states that many observers chose 370 foot-candles of illumination for comfortable reading. The readers viewed an illuminated page of a telephone directory through a small window in a black box. Nothing is said concerning the visual adaptation of the subjects. Little confidence can be placed in this uncontrolled experiment.

Several other experiments have been performed. Luckiesh, Taylor

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and Sinden (2), employing well distributed general illumination, found that subjects preferred on the average 5.3 foot-candles for reading 11 and 12 point type, and 10.6 to 16.1 foot-candles for 9 point. For a low degree of contrast between 9 point type and printing surface, 17.4 foot-candles were chosen when 30 were available. In another study with well diffused general illumination, Luckiesh and Taylor (3) obtained preferences of illumination intensities for reading 9 point type. With up to 8 foot-candles available, the readers chose 4.2; with 30, 10.6; with 45, 16.1; with 65, 23.2; and with 100, 35.8. It was concluded that the readers did not choose the maximum because they probably assumed that the desired intensity was somewhere between the extremes. This conclusion appears unwarranted since in the experiment cited above (4), in which preferences were made solely upon the basis of the reader's own criteria of comfort afforded by the lighting and with no suggestion that one's choice should avoid extremes, the median choice was only 50 foot-candles.

Why do such different choices appear when the reader expresses his preference for the illumination intensity best suited for comfortable reading? In the data cited above, there is a suggestion that visual adaptation at the time of the choice plays a dominant role in the choice. As the eyes are exposed to a greater range of intensities, partial adaptation to brighter illumination may occur and this can lead to a choice of more foot-candles for comfortable reading. It is well known that vision readily adapts to easy and efficient seeing within a wide range of illumination intensities. To test the hypothesis that visual adaptation influences the reader's preference for the illumination intensity best for comfortable reading, an experiment was carried out by Tinker (6). There were 144 readers tested. At one sitting a subject was adapted for 15 minutes to 8 foot-candles intensity and then chose, by the paired comparison method, between 8 foot-candles and each of the following intensities: 1, 2, 3, 5, 12, 18, 26, and 41 foot-candles. There was a four minute readaptation to the 8 foot-candles before each succeeding choice. At the other sitting, the subject was adapted to 52 foot-candles and then chose between 52 and each of the following intensities: 18, 30, 41, 46, 59, 62, 71, and 100 foot-candles. When adapted to 8 foot-candles, 8 foot-candles was preferred most frequently for easy and comfortable reading, but the median was at 12 foot-candles. Similarly, when adapted to 52 foot-candles, the median choice was for the intensity to which the subject was adapted. It seems clear that visual adaptation at the moment determines to a large degree the intensity preferred for reading under general illumination.

In a preliminary study of illumination intensities preferred for reading under direct lighting, Aasen, Burwell and Harmon (cited by Tinker, 7) obtained choices in a situation which approximated the light from the

old-fashioned type of bridge lamp. The reader explored over a range of from 1 to 50 foot-candles. When progressing from low to high intensities, the mean choice was 21.5 foot-candles; from high to low intensities, 28.9 foot-candles. In a similar study of preferences of illumination intensities for reading, Tinker (7) employed metal shade, flexible arm reading lamps which yielded strictly local illumination. The mean intensity chosen by the readers was 42.6 foot-candles when 3 to 160 were available. Although visual adaptation was not adequately controlled in either of these experiments, there are indications that variation in adaptation was influencing the results. There is need for further experimentation in this kind of situation with strict control of visual adaptation. This is done in the following study.

Description of Experiment

The purpose of this experiment is to determine illumination intensities preferred for easy and comfortable reading under strictly localized lighting when visual adaptation is controlled. The experiment was conducted in a light laboratory with no outside windows, hence rigid control of illumination was possible. Six standard, metal shade, flexible arm reading lamps equipped with regular frosted bulbs provided highly localized lighting. The fairly uniform spot of illumination on the reading stand was about 10 inches in diameter. From the perimeter of this area outward, the illumination decreased rapidly in intensity.

Sixty university students served as subjects. There were two sessions of 50 minutes for each subject. At each session, the subject was adapted to a certain standard level of illumination intensity. At one sitting this level was 20 foot-candles; at the other, 50 foot-candles. Half of the subjects began with the 20 foot-candles, the other half with 50 foot-candles.

The subjects observed one at a time. When a subject arrived at the laboratory, he spent 15 minutes adapting to the standard illumination (20 or 50 foot-candles). Near the end of this period, he was directed to do some sample reading of the printed material that was to be used in the experiment. This text (Winkler's Morgan the Magnificent) was printed in 11 point type with 2 point leading and a 23 pica line width on mat white paper. At the end of the 15 minute adaptation period the following directions were read to the subject:

"I am going to ask you to decide which of several brightnesses of light you prefer for reading. Decide in terms of the light which seems most comfortable for reading. You will be asked to read a few lines under a standard light—the one now on—and then under a comparison light. After trying this for a couple of times, you will choose which light you prefer for reading. Several lights will be compared with the standard."

Ten seconds after notifying the subject that the light now on was one of the lights to be compared, the standard was switched off and simultaneously the comparison light was switched on. Ten seconds later the whole procedure was repeated and then a choice asked for by asking, "Do you prefer this or this?". The subject was readapted for 2 minutes to the standard intensity before the next choice. The 20 foot-candle standard was compared with 4, 10, 50, 75 and 100 foot-candles in a random order. For every alternate subject the random order was different. The 50 foot-candle standard was compared with 4, 10, 20, 75 and 100 foot-candles with a similar randomized presentation. Thus each subject made five choices under each of the two conditions of adaptation.

The illumination intensities were checked every day with a recently calibrated General Electric Foot-Candle Meter to be sure that the intensities were accurate as planned.

Results

The frequency with which each intensity was chosen as best for easy and comfortable reading was computed. Since the standard intensity was compared with each of the five other intensities, it appeared five times as often as each of the comparison lights. It was necessary, therefore, to divide the frequency of choice for the 20 and for the 50 foot-candles by five to make these figures comparable with the others. The results, showing these adjusted data, are given in Table 1. In the first

Table 1

Illumination Intensities Preferred for Reading With Direct Lighting

Note: In top section of table, the 20 foot-candle light was compared separately with 4, 10, 50, 75 and 100 foot-candles. $N = 60$ university students. Under these conditions, 4 foot-candles were chosen 13 times (7 per cent) out of 184 effective choices; 10 foot-candles, 13, etc. The bottom section of the table is read in a similar manner. Here the standard was 50 foot-candles.

	Adapted to 20 Foot-candles					
Foot-candles Compared	4	10	20	50	75	100
Choice frequency	13	13	29	46	42	41
Percentage frequency	7	7	16	25	23	22
	Adapted to 50 Foot-candles					
Foot-candles Compared	4	10	20	50	75	100
Choice frequency	13	13	16	37	35	37
Percentage frequency	9	9	11	24	23	24

row of each part of the table are listed the intensities of illumination compared. Just below are given the frequencies with which each intensity was chosen as best for easy and comfortable reading of the 11 point type. Percentage frequencies are listed in line three. In reading the

table it should be remembered that each intensity was compared with the one to which the subject was adapted.

Examination of the data reveals that visual adaptation at the moment appears to determine to some degree the choices made, but that it does not play the dominant role found by Tinker (6) in the study employing general illumination. For instance, when adapted to 20 foot-candles, there were 29 choices (16 per cent) at 20 foot-candles. But when adapted to 50 foot-candles, there were only 16 choices (11 per cent) at the 20 foot-candles level. Before adjusting the data by dividing by five, there were 145 choices at 20 foot-candles when adapted to that intensity, and 186 choices at 50 when adapted to the 50.

When adapted to either 20 or 50 foot-candles, choices ranged from 4 to 100 foot-candles. But the dominant tendency in both sets of data is to prefer relatively bright illumination in this strictly local lighting situation. Thus, 50, 75, 100 foot-candles were chosen most frequently irrespective of the intensity to which the subject was adapted. The tendency to choose relatively high intensities for reading under strictly localized light agrees with an earlier finding (7).

This preference for relatively bright illumination for reading under strictly localized direct lighting has unfortunate implications for the hygiene of vision. It has been demonstrated that local direct lighting such as employed in this experiment is unhygienic (5). A small spot of bright light surrounded by dimly illuminated areas and shadows in the visual field provides a situation that rapidly produces visual fatigue. It is the lack of uniform distribution of illumination in the visual field that is bad. In a situation of this kind, the greater the intensity of illumination, the worse it becomes for visual work since the demarkation between the small bright area and the dimly illuminated surroundings becomes more pronounced. In fact, the subjects in the earlier experiment on direct lighting (7) were much disturbed by the uneven distribution of illumination in the visual field, especially when higher intensities were employed. Nevertheless the readers do choose the higher intensities under the direct lighting.

Literature on the subject (5) points out that when local lighting is employed it should be supplemented by general illumination to avoid an undesirable degree of brightness contrast within the visual field. This hygienic principle is unknown to many and frequently ignored by others. It is of some importance, therefore, to point out that the undesirable features of such a situation are accentuated as the light intensity is increased. Apparently, therefore, it is unsafe to follow individual preferences as to what seems to be the best intensity for comfortable reading with strictly local lighting. If such a light is used, relatively low intensities produce less visual fatigue.

Summary and Conclusions

1. A survey of the literature reveals a wide range of intensities of illumination chosen as best for comfortable reading under general lighting. Visual adaptation at time of choice largely determines the intensity preferred.

2. The purpose in this experiment was to determine the effect of visual adaptation upon illumination intensities preferred for reading under direct lighting that is strictly local.

3. The illumination used was derived from standard metal shade, flexible arm reading desk lamps. Range of illumination available was from 4 to 100 foot-candles.

4. Sixty subjects observed at two sittings. At one sitting they were adapted to 20 foot-candles; at the other, to 50 foot-candles. After adaptation, each subject chose between the standard to which he was adapted and each of five other intensities on the basis of the intensity preferred for easy and comfortable reading.

5. Visual adaptation at time of choice influenced the choice only moderately.

6. There was a marked tendency to prefer intensities at and above the brightness to which the subject was adapted. This resulted in frequent choice of high intensities.

7. Since, in direct lighting such as used here, bright intensities make a bad situation worse from the viewpoint of hygienic vision, preferences for illumination intensities for reading yield unsatisfactory data for prescribing lighting for the individual.

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Mechanical Aptitudes of University Women

Lillian G. Portenier

The University of Wyoming

With wartime economy demands emphasizing the already existing educational and cultural needs for greater mechanical training for university women the Detroit Mechanical Aptitudes Examination was administered to four hundred twenty-five women students at the University of Wyoming during the winter quarter 1942–1943. The revised edition was used. The Detroit test was chosen since, according to the authors, many of the items appeal to girls making the test suitable for both sexes. The same set of norms is used for the two groups. The variation of only one to two per cent between the sexes was not believed to be sufficient to warrant complete sets of separate norms. No appreciable difference could be detected in the median scores.

The similarity in achievement for both sexes for the Detroit test differs markedly from the results found for the Stenquist Assembling Test. Stenquist (8) reports that elementary school girls obtained only about 65 per cent as many correct items as boys, and that women in graduate school obtained about 80 per cent as many correct items as unselected adult men. Similar differences were found in an extensive investigation in which the Minnesota Mechanical Aptitude Tests (7) were used with seventh grade boys and girls, and sophomore men and women in the college of Science, Literature and Arts at the University of Minnesota. The scores made by the university women were about the same as those made by seventh and eighth grade boys. The differences were most marked in a mechanical assembly test and in comprehensive tests of mechanical information. In general, the difference in males over the females increased somewhat in the older groups.

At the present time the available data appear to be inadequate to indicate whether differences in mechanical aptitudes between sexes or between individuals within each sex are due primarily to differences in general ability or to a special ability or abilities. Freeman (5) states, "One may well question whether it is appropriate to speak of mechanical ability as dissociated from general ability, that is, as a special ability." The results of the Detroit Mechanical Aptitudes Examination administered to the women students at the University of Wyoming were analyzed largely for the purpose of throwing further light on this question.

Of the women tested 48 per cent were freshmen, 24 per cent sophomores, 15 per cent juniors, and 13 per cent seniors. There are eight subtests in the Detroit Examination. Tests two and eight were designed to measure Motor Ability; tests three, five, and seven, Visual Imagery; tests one and six, Mechanical Information, and test four, Arithmetic. The "norms are based on ten thousand scores, chiefly the unselected groups of pupils at the eighth and ninth grade levels in Detroit. However, the examination has been given also to several hundred mentally subnormal children, to some normal fifth and sixth grade pupils, and to small groups in the senior high school as high as the twelfth grade."

Table 1

Medians, Means, Standard Deviations, Ability Ages and Ratings for the Scores on the Detroit Mechanical Aptitudes Examination, and the Ohio State University Test, for University Women

Test	Number	Median	Mean	S.D.	Age	Ratings
Detroit Mechanical Aptitudes						
Part I, Motor Ability (Tests 2, 8)	425	60.00	59.80	8.45	19–3	A, Very Superior
Part II, Visual Imagery (Tests 3, 5, 7)	425	91.11	85.25	17.55	17–2	B, Superior
Part III, Mechanical Information (Tests 1, 6)	425	50.29	49.85	8.85	16–9	B, Very Good
Part IV, Arithmetic (Test 4)	425	30.87	30.94	6.30	18–8	B, Very Superior
Total Scores (Tests 1–8 inc.)	425	229.26	225.68	30.66	17–5	B+, Superior
O.S.U. Psychological						
Part II, Analogies	396	30.56	31.00	11.65		53%ile
Total Scores (Parts I–II–III)	396	80.00	80.25	25.31		55%ile

Since the Ohio State University Psychological Test is administered to all students at Wyoming as high school seniors or after enrolling at the University the results of this test on file in the personnel department were used as a basis for determining the general mental ability of the women used in this study. The medians, means, standard deviations, mechanical ability ages and ratings for the scores on the subtests and on the total test for the Detroit Examination, and for Part II, analogies, and for the total score on O. S. U. Test are shown in Table 1. The mean percentile rank on the O. S. U. Test for the group is strong average on the basis of the national norms. In comparison with the norms for the Detroit Exam-

ination the median and mean scores were above average on all of the subtests and also for the total score on the test. The lowest mean score was achieved on the tests which were designed to measure Mechanical Information and the highest score on the tests for Motor Ability. The mean score for Part IV, Arithmetic, also was very superior. As indicated by Table 2, 72.5 per cent of the women earned superior scores on the mechanical aptitudes tests, and with the exception of but one woman the remaining 27.5 per cent earned average scores. This group of women was above average in mental ability as well as in mechanical aptitudes and a definite relationship between the scores was evident.

The superior results for this group of women may be due in part to the fact that the norms of the Detroit Examination are based chiefly on unselected groups of junior high school pupils. However, in no case did

Table 2

Rating of 425 University Women on the Detroit Mechanical Aptitudes Examination and the O.S.U. Test

Rating on O.S.U. Test	Rating on Detroit Mechanical Aptitude Test		
	Inferior Below 20%ile	Average 20 to 80%ile	Superior 80%ile and Above
Superior 80%ile and Above	0%	.7%	15%
Average 20 to 80%ile	.2%	20%	55%
Inferior Below 20%ile	0%	6.6%	2.5%

the test fail to measure the limit of ability on any of the subtests since none of the women earned perfect scores on any of them.

To study further the relationship between the results on the tests for mechanical aptitudes and mental ability, product-moment correlations were computed between the scores on various tests and subtests. These correlations are shown in Table 3. With the exception of the tests for mechanical information and motor ability the correlations found are higher than those found for most other similar studies in which comparisons were made between mechanical aptitudes and general mental ability.

Stenquist (8) reports a correlation of .23 between the Stenquist Assembling Tests and a composite score from six verbal intelligence tests in a group of 267 seventh and eighth grade boys. The same correlation viz. .23 was found in this study between the subtests for Motor Ability and the total O. S. U. Test. The Stenquist Assembling Tests are far more mechanical in character than the Detroit tests. They are not of the paper and pencil type. They involve the construction of common

mechanical objects from given parts such as a mouse trap, door lock, clothespin, and bicycle bell. Since a correlation of .23 indicates a very slight degree of relationship Stenquist concludes that mechanical aptitude seems to be a special ability. A correlation of .13 was found by Paterson (7) for 100 junior high school boys between I. Q.'s estimated from socres on the Otis Intelligence Test and the scores obtained from a mechanical aptitude battery, composed exclusively of apparatus or manipulation tests. For the Minnesota Paper Form Board Test, which is a paper and pencil test of the ability to handle spatial relations, and a vocabulary test Anastasi (1) obtained a correlation of .07 for 225 male college students.

The O. S. U. Test and the Detroit Examination appear to have more in common than the tests in the studies just cited. The higher correlations found may be attributed to the common influence of the comprehension of verbal directions, knowledge of words, and general facility with verbal material. This conclusion seems to be supported by the

Table 3

Correlations Between Scores on the Ohio State University Test and the Detroit Mechanical Aptitudes Examination for University Women

Detroit Mechanical Aptitudes Examination	Total O. S. U. Test	Part II, O. S. U. Analogies
Part I, Motor Ability	.23 ± .032	
Part II, Visual Imagery	.42 ± .026	.38 ± .028
Part III, Mechanical Information	.09 ± .033	
Part IV, Arithmetic	.43 ± .025	.40 ± .027
Total Test, Mechanical Aptitudes	.53 ± .024	.47 ± .024

relatively high correlations found between certain subtests and the total of the Detroit Mechanical Aptitudes Examination and the total scores and Part II, Analogies, of the O. S. U. Tests. As shown in Table 3 the correlation of the total O. S. U. Test with Visual Imagery is .42, with Arithmetic .43 and with total Mechanical Aptitude scores .53. Between Visual Imagery and Analogies it is .38, Arithmetic and Analogies .40 and between the total Detroit test and Analogies it is .47. The authors report a correlation of .65 between the Mechanical Aptitudes Examination and the Detroit Advanced Intelligence Test.

Part I of the O. S. U. Test is largely a measure of vocabulary; Part II, analogies, was designed to measure a combination of reasoning ability, spelling, capacity for logical associations and knowledge of grammatical forms; and Part III is primarily a test of ability to read difficult passages. Part II would seem to have most in common with the Detroit Examination since little vocabulary is involved and none of the subtests call for ability to read difficult passages.

The findings from the data presented in the present study tend to support Guilford's (6) conclusion. He states, "Strange as it may appear, there seem to be no special abilities of speed, learning, musical talent or mechanical bent. ———Musical talent is very complex and so is mechanical skill." Thus, while the correlations between verbal and numerical tests generally have been found to be low a higher relationship may result when both tests involve similar abilities, such as ability to follow directions as appears to be the case, to some extent, with certain subtests in the Detroit and Ohio tests, and to an even greater extent between the Detroit Advanced Intelligence Test and the Mechanical Aptitudes Examination.

That mechanical aptitudes are a complex of skills and abilities rather than a unitary special ability is further indicated in a study of "Sex differences in the understanding of mechanical problems" by Bennett and Cruikshank (4). They found women slightly superior to men in tests of manual performance if dexterity is involved, and men clearly superior in tests of mechanical assembly, or if strength is needed. Again, the superiority of men was not so marked in tests involving perception of spatial relations as the Minnesota Paper Form Board or the Minnesota Spatial Relations Test. Subtests 2 and 8, designated as tests of motor ability in the Detroit Examination, involve dexterity, and subtests 3, 5 and 7 termed tests of visual imagery depend to some extent on the perception of spatial relations. Bennett and Cruikshank (3) state, "Tests which require speed and accuracy in simple perceptual discriminations and in simple motor tasks show slightly better scores for girls. In tests of strength, boys are superior. In more complicated perceptual and spatial tasks, boys also score higher. ———To a large extent there can be no doubt that the superiority of boys in tests of mechanical ability is a function of our present system where women are ordinarily not expected to deal with certain types of mechanical contrivances nor encouraged to do so. When it happens, as it does in a war period, that women are called upon to do some of these things, their performances are far more creditable than might have been expected."

Just as an I.Q. derived from one battery of mental tests does not signify the same thing necessarily as an I.Q. from another battery so the scores resulting from different tests of mechanical ability may be indicative of widely varying aptitudes or skills. The results analyzed in this study seem to indicate that the mechanical abilities measured by the Detroit Mechanical Aptitudes Examination are not dissociated completely from general college ability as measured by the O. S. U. Test when the abilities measured are those of university women.

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Aptitude and Interest Patterns of Art Majors in a Liberal Arts College

Dorothy M. Barrett

Hunter College of the City of New York

Many students in college have difficulty in choosing a field of specialization. Often young people who succeed in electing a field of specialization later change their minds one or even several times. Even when they make decisions and follow through with them, students frequently later regard their choices as mistakes. Much energy and ability are wasted because students fail to find fields of study and work for which their aptitudes and interests suit them.

This paper describes a study, part of a larger project, which was undertaken with the intention of trying to discover whether or not a group of juniors and seniors who were majoring in art in a liberal arts college could be differentiated by means of a battery of tests from a group of juniors and seniors majoring in other fields within the same institution. The study was undertaken with the assumption that a *battery* of tests would be necessary to obtain satisfactory predictions inasmuch as success in an academic or occupational field is likely to depend upon a number of aptitudes and interests and not upon any single ability.

If it proved possible to differentiate art majors from a group of control subjects by means of psychological tests, then it was proposed, after further checking the results, to use the battery of tests as diagnostic measures in advising underclassmen who consider art as a major but who, in spite of having been accepted by the art department, still feel uncertain about the wisdom of their choice.

Psychologists who are concerned with the problems of the vocational and educational guidance of students in colleges of liberal arts may find something helpful in the results of this project. The critical scores obtained in this study may not be the best ones for another institution because the predictive value of any scores would differ for each institution, depending upon the curriculum in which the test program is used, the number and types of specializations offered, the admission and academic standards of the college and the kind of art training given. However, a report of the results on those tests which proved useful in identifying art majors may prove valuable to other workers faced with advisory problems.

Subjects

In response to a request for volunteers, forty students in the art major and an equal number of upperclassmen specializing in other fields took the battery of tests. The art majors were students who, as juniors and seniors, had obtained satisfactory grades in their field of specialization and were quite satisfied with their choice of art as a major. The control group represented juniors and seniors in other majors who also expressed satisfaction with their fields of specialization. Subjects in both groups were interested in the tests, having been advised that they could learn their scores at a future date. All students were girls, students in Hunter College of the City of New York.

Tests [1]

The tests which were administered to both the art majors and the control subjects included Meier's Test of Art Judgment (1940 revision), Strong's Vocational Interest Blank for Women, the Study of Values, Series BB of the Revised Minnesota Paper Form Board and the Guilfords' Prognostic Test for Students in Design.[2]

Scores were available for all subjects for the Psychological Examination of the American Council on Education, administered at the time of admission to college. For a considerable number in the group, records were available of the scores on Greene's Michigan Vocabulary Profile Test which had been administered shortly after a student's admission.

Results on Meier Art Judgment Test

The distribution of test scores made by the art majors on the Meier Art Judgment Test overlaps markedly with the distribution of scores for the control subjects. As a group, however, the students specializing in art make higher scores than do the control subjects. The average score for the art majors is 109 while the average for the control group is 103. Using Fisher's *t*-test for measuring the significance of the difference in the means of independent small samples, *t* equals 2.6, indicating that the difference is significant at the 1% level.

There are other more useful differences between the two groups, however. A study of the distribution of ungrouped scores resulted in the establishment of two critical scores. A minimum score of 99 eliminates a fair number of control subjects while discriminating against only two art majors. A score of 107 and over singles out a considerable proportion

[1] The author is indebted to Miss Adele Linker for assistance in scoring the tests and to the Bureau of Educational and Vocational Guidance of Hunter College of the City of New York for sponsoring this study.

[2] Guilford, J. P., and Guilford, R. B. A prognostic test for students in design. *J. appl. Psychol.*, 1931, **15**, 335–345.

of the art majors while including only a small number of the control group. Thus, there are three significant ranges of scores.

Each subject in the experiment was classified in one of the three ranges of scores, according to whether her score was below 99, from 99 to 106 inclusive, or 107 and over. Figure 1 shows the results of such a classification. The number of control subjects in each range is indicated by the figures to the left of the line within the bar. The number of art majors in the same range of scores is represented by the figures to the right of the line within the bar. The per cent at the left end of each bar is the percentage which the control group represents of the total group scoring within the limits indicated. The per cent at the right of each

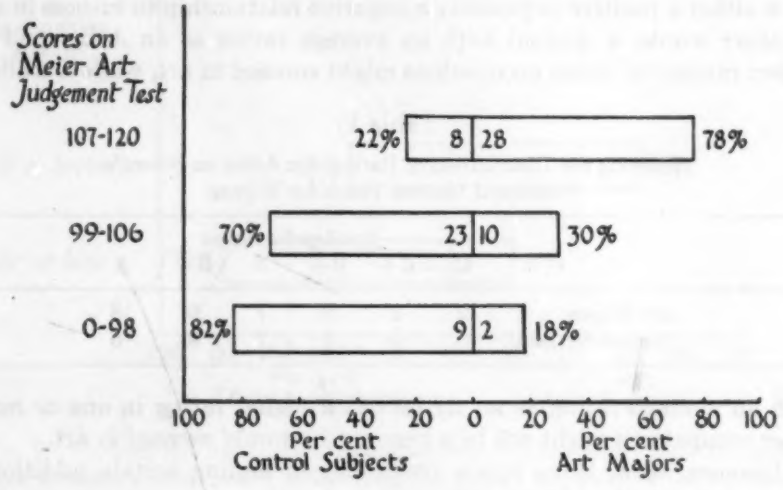

FIG. 1. Showing how many were control subjects and how many were art majors of those students scoring within certain ranges of scores on the Meier Art Judgment Test.

bar is the percentage which the art group represents of the total group scoring in that category.

Reference to Figure 1 indicates that 11 subjects had scores below 99 on the Meier Art Judgment Test. Of this group having low scores, 82% are control subjects and 18% are art majors. Of the subjects having scores from 99 to 106 inclusive, 70% are control subjects and 30% are art majors. On the other hand, of the subjects with scores of 107 and over, only 22% are control subjects while 78% are art majors.

On the basis of this study, any student scoring up to and including 98 on the Meier Art Judgment Test would have only 18 chances in 100 of being a successful and satisfied art major in Hunter College. If her

score is between 99 and 107, her chances of being an art major in the same institution are still only 30 in 100. However, if a student has a score of 107 and over, her chances of being an art major are more than double, then being 78 in 100.

Results on Vocational Interest Blank for Women

The usual method to be followed in attempting to differentiate between the two groups in this study would be to use only the ratings for Artist on Strong's Vocational Interest Blank for Women, with the expectation that there would be more high ratings for Artist among the art majors than among the subjects of the control group. However, the author believed that high scores on occupations other than Artist might show either a positive or possibly a negative relationship to success in art. In other words, a student with an average rating as an Artist and no higher ratings for other occupations might succeed in art, while a student

Table 1

Showing the Distribution of Ratings for Artist on Strong's Vocational Interest Blank for Women

	Ratings for Artist					
	C	C+	B−	B	B+	A
Art Majors	2	2	2	7	9	18
Control Subjects	6	9	7	7	5	6

with an average rating as an Artist but a higher rating in one or more other occupations might not be a person who would succeed in art.

Because, then, there was a possibility of finding certain additional relationships which might differentiate between the two groups, the blanks were machine scored for all occupations. The writer studied carefully the distributions of letter grades for the art majors and for the control subjects for each of the 17 occupations on the test. The ratings for several of the occupations did differentiate between the two groups. It was concluded, however, that the additional differentiation on the basis of the extra scores was insufficient to warrant, for future counseling services, the expense of the extra scoring required. The remaining discussion, therefore, is limited to a consideration of the scores for Artist.

The art majors and the control subjects obtained rather different ratings for Artist. The tabulation of the letter ratings for each group is given in Table 1. Reference to the table indicates that only six of the forty art majors scored B− or less as Artist while twenty-two of the control subjects had such low ratings. Thirty-four of the art majors scored B or better, while only eighteen of the control subjects had such high

ratings. In other words, high scores for Artist on the Strong test are more often than not associated with successful specialization in art.

Figure 2 shows that a student's chances, according to the results of this study, of being a successful and satisfied art major are only 21 in 100 if she has a rating of B− or less. If she rates B, B+ or A, her chances of being a satisfactory and satisfied art major become 65 in 100.

Results on a Study of Values

Keeping the control and experimental groups separate, a study was made of the distributions of the scores for each value on the Allport and Vernon Test.

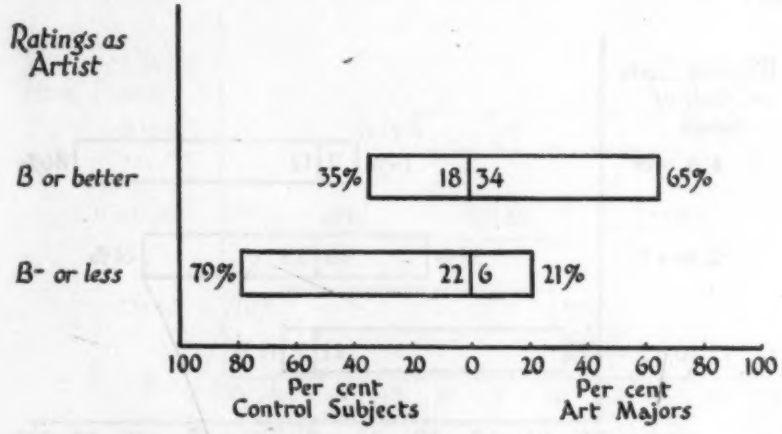

FIG. 2. Showing how many were control subjects and how many were art majors of those students scoring within certain ranges of ratings for Artist on the Vocationa Interest Blank for Women.

The art majors and control subjects, while yielding overlapping distributions, did nevertheless show certain differences. Both groups had very high scores on the Aesthetic scale, but a greater number of the art majors scored at the extreme end of the scale than did the control subjects. More control subjects had extremely low scores on the Aesthetic value than did the art majors. Taking into consideration the relative number of art majors and control subjects at each end of the scale, a score of 46 and over was given a value of +2 and a score of 32 or less was assigned a weight of −3. In like fashion, weights were worked out for the other values on the test. On the basis of these weights, it was theoretically possible to have a total weighted score for the Study of Values varying from −17 to +12. Actually, the scores varied between −13 and +8.

A study of the distributions of the weighted scores led to the establishment of certain critical scores which were used to set up ranges of scores that were significant. The extent to which the experimental and control groups differed is indicated in Figure 3.

A total of 25 students had scores between −13 and −2. Of this group, 88% were control subjects and only 12% were art majors. On the other hand, in the group having very high scores of 4 and over, 86% were art majors and only 14% were control subjects. The middle range of scores included more equal proportions of art majors and control subjects, the exact proportions being shown in Figure 3. (The figures inside the bar again indicate the number of cases upon which the per cent is based.)

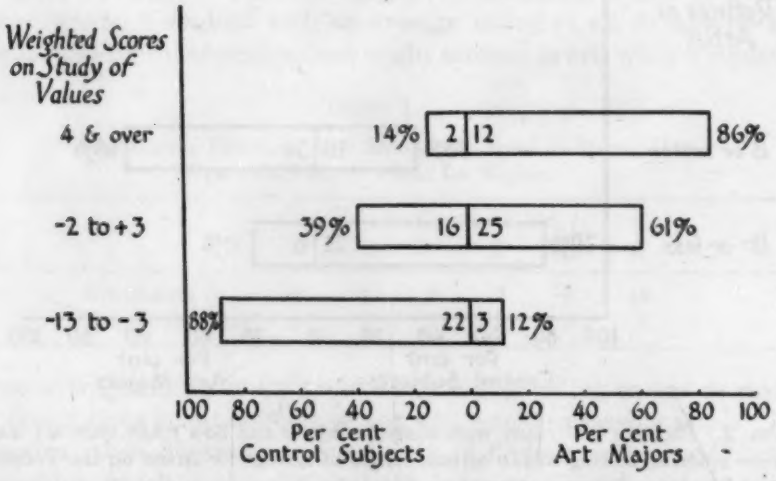

FIG. 3. Showing how many were control subjects and how many were art majors of those students scoring within certain ranges of total weighted scores for the Study of Values.

Weighted scores on the Allport and Vernon Test differentiated well between the art majors and the control subjects. On the basis of this test alone it is possible to give a fair estimate of a student's chances of being an art major. The average score for the art majors was +2 and for the control subjects it was −3. Again using the *t* for small samples, we find that the difference between the averages is significant at the 1% level.

Results on Revised Minnesota Paper Form Board

Series BB of the Revised Minnesota Paper Form Board was included in the battery of tests administered to the subjects on the assumption that the ability measured might be one of the aptitudes contributing to

successful composition, as well as contributing to success in such specialized courses in the art major as drafting and lettering.

The control and experimental groups had rather similar scores on this test of spatial relations. The average score for the control subjects was 43 and for the art majors was 47, a difference which is small but significant at the 5% level. As indicated in Figure 4, 79% of the group scoring below 41 were control subjects, while only 21% of the group were art majors. At the other end of the distribution, 72% of those students scoring 51 and over were art majors and only 28% were control subjects. The middle range of scores included approximately half art majors and half control subjects.

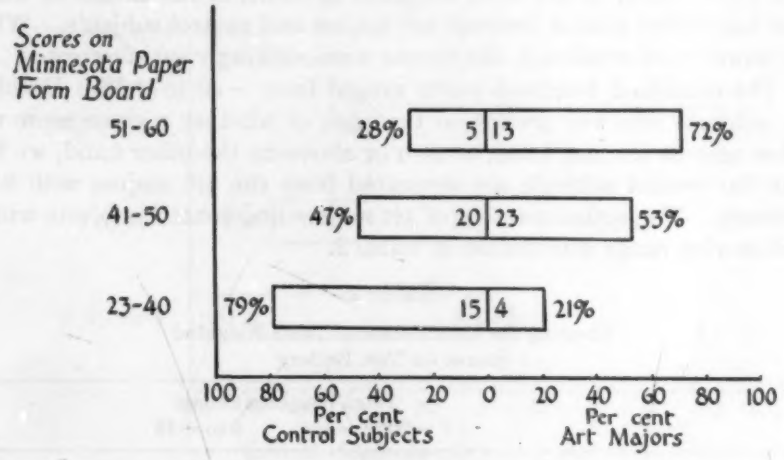

FIG. 4. Showing how many were control subjects and how many were art majors of those students who scored within certain ranges of scores on the Minnesota Paper Form Board.

Extreme scores on the Revised Minnesota Paper Form Board test were significant in differentiating between art majors and control subjects. This test gave results sufficiently diagnostic to be included in a final battery of tests.

Results on Other Tests

The experimental and control groups had identical Q, L, and Total scores on the A. C. E. Psychological Examination. The two groups did differ, however, on the Michigan Vocabulary Profile Test. Analysis of the profile scores made by the students when they were freshmen indicates that for the Fine Arts Vocabulary section the average score for the students who later became art majors was higher than the average score of those students who later majored in other fields. Because scores were

not available for all subjects, however, the test was not included as one of the predictive measures in the final battery of tests.

The Guilfords' Line Drawing Test, which was included in the experiment, brought out some interesting differences between the two groups. The test appeared to measure a certain creative ability which the other tests did not touch. However, the subjectivity of the scoring of the test proved too great an objection to its use in practical circumstances.

Results of Four Tests Combined

The scores from Meier's Test of Art Judgment, Strong's Vocational Interest Blank for Women, the Study of Values and the Revised Minnesota Paper Form Board were weighted in terms of the extent to which each test differentiated between art majors and control subjects. When the scores were combined, the results were strikingly satisfactory.

The combined weighted scores ranged from −20 to +18. Dividing the subjects into two groups on the basis of whether a given score was below zero on the one hand, or zero or above on the other hand, we find that the control subjects are separated from the art majors with 85% accuracy. The actual number of art majors and control subjects within each scoring range is indicated in Table 2.

Table 2

Showing the Distribution of Total Weighted Scores for Test Battery

	Total Weighted Scores	
	−20 to −1	0 to +18
Art Majors	4	36
Control Subjects	32	8

Ordinarily, psychological tests pick out the failures more readily than the successes. A minimum score is often necessary for success. Not as often does a high score mean success. The tests used in this study have, however, tended to identify the art majors in positive fashion as well as to identify those students least likely to possess such a pattern of aptitude and interest.

It should be pointed out that some of the scores made by the art majors may be spuriously high. It is possible that the scores on the test of Art Judgment and on the Revised Minnesota Paper Form Board may be higher than would ordinarily be the case just because the students have been studying art. To what extent the differences established in this study would be substantiated if subjects were given all tests at the beginning of their college courses is at present a matter of conjecture. The author is carrying out a study to check on this point.

Meanwhile, however, the distribution of the combined scores warrants further consideration. According to the results indicated in Figure 5, no art majors were included among the eighteen students having the lowest scores, the tests thus predicting 100% accurately for this range of scores. Eighty-five per cent of those subjects having high scores were art majors, a very satisfactory degree of differentiation between the two groups.

A study of the five control subjects included in the range of scores which was generally typical of art majors leads the writer to wonder if the tests may not be even more successful than the figures have indicated. Reference to interview notes jotted down at the time the subjects took

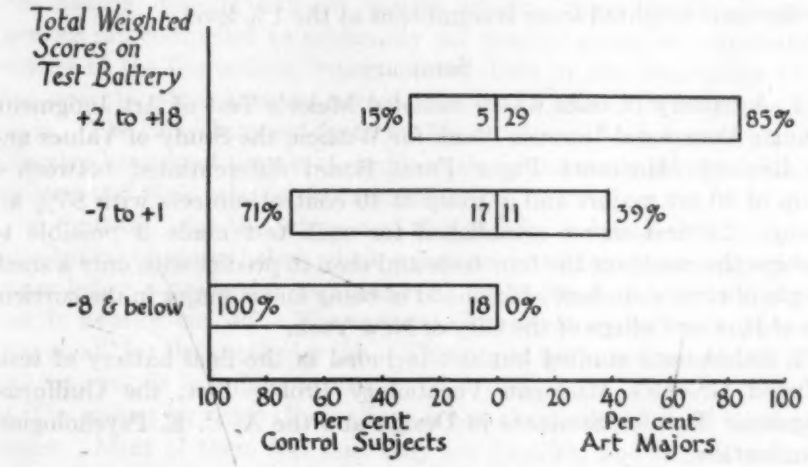

FIG. 5. Showing how many were control subjects and how many were art majors of those students scoring within certain ranges of composite weighted scores on the test battery.

the tests or reported for their scores shows that one control subject who scored high on the battery of tests was an art major originally, but changed to another field because of a personal experience which had turned her against the study of art. It seems fair to conclude that she had reacted against personalities and not against art as a major. This girl was evidently not a fair control subject if what we are trying to predict is interest and ability in the field of art.

Another control subject just recently discovered a flair for art. She is continuing her present major but has decided to include as many art courses as possible in her program. Very probably she would have made a satisfactory art major if she had become aware of her aptitudes and interests earlier.

A careful study of the aptitude and interest patterns of several of the art students who fell outside of their group on the basis of the total weighted scores on this battery of tests leads the author to conclude that although the students are satisfied with their majors, they might have done better work and been better satisfied in other fields. For example, one art major seems to have a flair for science, a fact which she never realized and never followed up. It is possible that it is significant that this student had scores more similar to the scores of the control subjects than to the scores of the art majors.

In conclusion, then, it can be stated that the total weighted scores on this battery of tests differentiated clearly between the art majors and the control group. The difference between the averages of the two groups for the total weighted score is significant at the 1% level.

Summary

1. A battery of tests which included Meier's Test of Art Judgment, Strong's Vocational Interest Blank for Women, the Study of Values and the Revised Minnesota Paper Form Board differentiated between a group of 40 art majors and a group of 40 control subjects with 85% accuracy. Critical scores established for each test made it possible to combine the results of the four tests and then to predict with only a small margin of error a student's likelihood of being an art major in the curriculum of Hunter College of the City of New York.

2. Other tests studied but not included in the final battery of tests included Greene's Michigan Vocabulary Profile Test, the Guilfords' Prognostic Test for Students in Design and the A. C. E. Psychological Examination.

3. No differences were found between the control and experimental groups for either the Q, L, or Total scores on the Psychological Examination. On the Michigan Vocabulary Profile Test, which had been administered to many of the students at the time of their entrance to college, the art majors ranked higher than the control subjects on the Fine Arts Vocabulary section. Because scores were not available, however, for all 80 subjects, the test was not included in the final battery of tests for which a weighted total was obtained.

4. The Guilfords' Line Drawing Test was administered to all subjects. A kind of creative ability seemed evident in the data, suggesting interesting possibilities for further analysis. However, evaluation of the records for this test is too subjective at this stage to warrant the inclusion of the test in a battery of tests for immediate practical use.

Received November 22, 1944.

Merit Examination Cut-Offs and Weights

Wm. Thos. Toolan

Supervisor of Recruitment, Los Angeles City Board of Education

Although the Merit System has made much progress during the last few years, it still faces the problem of shaking off some of its inheritances such as setting weights and passing marks in advance of examinations, and making cut-offs without careful study. Some public personnel agencies are compelled to arbitrarily set weights ahead of examinations because of the limitations imposed upon them by the laws under which they operate; other agencies accept this sort of procedure because others use it. The procedures set forth in this article will be found to be fairly objective because of the use of simple analysis and study of parts of examinations and their relation to each other.

A "cut-off," for the purpose of this article, is a line on a frequency distribution of scores below which scores are considered as not acceptable or are below a predetermined standard. The lower tail of the distribution is usually cut off. The upper tail represents persons supposedly "too good" for the particular job. This upper tail is not considered when making cut-offs in public service.

The reason for these eliminations is not always understood by the job seeker. Most of them feel that they are qualified and therefore should be on the employment list. The recruitment office, of course, has definite reasons for making an elimination after each part of an examination, and just before the eligible list is established.

Applicants are not always told the real reason why their names do not appear on the list. They are often told that "the size of the list did not warrant placing their names upon it." This would imply that "the size of the list is based on our anticipated needs." No matter how a notification of standing, that tells the applicant his name is not on the list, is worded, it means to him that he has failed in the examination. This generally makes for ill feeling with the public.

Elimination at each step of the examination is ordinarily done for the purpose of getting rid of unfit applicants. The final elimination should be made on the basis of including all qualified applicants. That is, no matter what the needs or anticipated needs might be, all qualified applicants should appear on the eligible list. The excuse of the recruitment or assignment office that it entails some additional clerical work hardly

seems sufficient. For the sake of public relations, it is well that elimination of applicants seeking jobs in the public service be done more carefully and scientifically than heretofore.

Before starting to make a cut-off, it would seem that a knowledge of what had taken place to give us these scores in the distribution would be a *sine qua non*. If we have not formulated the specifications, drawn up the test, administered or analyzed it, we should get in touch with those who have done so. We are now qualified to take the first step in making the cut-off. This tentative cut-off will be a guess, backed up by the supporting data which we have at hand.

A Tentative Cut-Off

Around, or somewhat above and below this tentative cut-off, will be found test papers none of which are exactly alike. If the test is a written one or a practical (performance), the results for each candidate will be different although they may have the same score. One will have missed items which the other or others will have gotten right. If we have made too low a cut-off, we will be in the midst of a lot of poor papers. If we have made too high a cut-off, the papers will, generally speaking, be quite acceptable. Thus, we may have to move up or down and make several test cut-offs before we arrive at a place where we are fairly sure that we have neither done any great injustice nor included any obviously unfit papers.

If there are many vacancies or anticipated vacancies and there is a dearth of applicants, we may be forced to include more above the cut-off than we would otherwise. Or, if there are few vacancies, or anticipated vacancies, we will probably not want to carry an excessive number through the remaining parts of the examination. There is great danger in picking up the unqualified when making a low cut-off, and there is danger in building ill feeling by failing a large group of qualified persons when making an unnecessarily high cut-off.

A Typical Example

What one runs into can be seen by examining a group of practical papers for say stenographers. Among some obviously unfit papers is found a paper which on close examination shows that the contestant did very poorly at the beginning of the test and gradually got better toward the end in spite of the fact that there was an increase in words per minute. This was not due to lack of "warm-up" as we find that ample practice dictation was given prior to taking the test. To those who are experienced in giving stenographic tests, these thoughts would immediately come to mind: Taking in shorthand and transcribing are different steps. The longer the test, the greater the possibility of the first part of the notes

getting cold. The testee who lacks a vocabulary of sign words or lacks retention will not be able to read much of the first part of her notes because they are colder. No matter how fast one can take shorthand, if she cannot transcribe or read her notes when they are cold, they are of little value to anyone.

Many limitations are imposed on one who is attempting to make a scientific cut-off for a practical test. It is impossible to assume a purely objective attitude. Persons scoring typing or stenographic tests do not rate exactly the same. Testees often make the same error but under different circumstances. One stenographic testee omits five words of dictation and patching it up submits an acceptable letter, another makes the same error but makes no attempt to "fill in." They are penalized alike.

Although approximately the same *modus operandi* may be used in making cut-offs, no two are made in exactly the same manner. The more we study the peculiarities of the papers, whether written or practical, the more we are in doubt regarding the manner in which this or that answer was chosen in an item of a written test, or just why this otherwise good practical test was spoiled by the testee doing something unusual or out of the ordinary.

Ordinarily an examination includes a written and an oral part. Sometimes a practical test follows the written, and occasionally a practical and oral is used. This last combination is used where the practical is broad enough to test for the degree of skill needed for the job. However, where it is necessary to test for technical knowledge, a written test is used. The oral test is ordinarily used as a test of general fitness for the job. It includes evaluation of personal characteristics, and education and experience.

When Parts Should be Weighted

The weighting of parts of an examination before it is held can hardly be anything other than an estimate of the results of the examination. For instance, the written is compiled and intended to test for certain things, but after it is administered, and the results thereof studied, it is found that it has failed to come up to expectations. The distribution of scores may show clearly that it is too easy or too difficult for the group. This would, then, make a difference in the weight assigned it. Ineffective rating on the part of oral or practical test raters should be cause for lowering the weights of these parts, whereas otherwise they would be assigned higher weights.

Where an agency uses the same written and other parts of an examination, and the same rater requirements, and the quality of the applicants remain the same, about the same results can be expected. This being

the case tentative weights may be set subject to study after all parts of the examination have been completed.

The weight of an examination part will vary when studied in the light of the requirements for the job. Examples of extremes, say for personal characteristics requirements, would be "secretary" and "billing machine operator." Although studies have shown that the majority of employees are unsatisfactory because of personal characteristics, we must admit that the degree to which personal characteristics are important will vary with the job. Thus weights for the parts of an examination will depend upon the nature of the position for which the examination is given.

The question as to the effectiveness of a part in an examination probably is the least objective step in determining its weight. All considerations of the examination are kept in mind and the paired comparison method of ranking employed. In other words, this phase of the study presupposes a thorough knowledge of all that has any bearing or throws any light on the examinations. It is backed up by applicable information, or supporting evidence.

If the written test has been administered and studied as to reliability, it can be relied upon to give about the same results each time it is used, provided the requirements for admission to the test have not been changed materially. The practical is probably the easiest of all the parts of an examination to size up as to its effectiveness, depending, of course, upon the raters, the nature of the test, how elaborate it is, etc. In all parts of an examination, with the exception of the written, evaluation of effectiveness is based on observation, and, of course, distribution of scores.

As soon as we affix a weight to a part of an examination we indicate that it has been considered in relation to the other part or parts of the examination. Its importance or effectiveness, then, is reflected in the weight assigned it. When an attempt is made to consider a part without first considering the other parts, the other parts may be left with too small or too large weights. That is to say, if we insist that written parts have low weights affixed to them, we are apt to find that the oral interview parts have been given excessive weights.

What Weights Do

If a part of an examination is important or effective, it should be weighted accordingly. When a part has proven itself worthy of the heaviest weight in an examination, and such a weight has been assigned it, it becomes the controlling factor of the relative placement of persons in the final distribution, or the eligible list. Thus the greatest weight in an examination will tend to move persons on the final distribution a greater number of places than will the smallest weight assigned. What

weights will do can be brought home most effectively by reversing assigned weights and observing the results.

Frequency distributions of parts of examinations vary to the extent that no two are identical. This means, then, that their spreads and "forms" are instrumental in shaping final distributions and eligible lists. A distribution of a part which has a tendency to be bunched (skewed) upward or downward or for any reason does not have a good spread of scores has set a comparatively low weight for its part, and should be weighted accordingly irrespective of what weight has previously been forecast for it.

The setting of weights for examinations in other than a careful manner is apt to spoil everything that has gone before. Such *a priori* methods as are sometimes used because of carelessness or ignorance of a few simple rules, are not in accordance with the merit system because they have a tendency to place persons on eligible lists out of the order of their relative excellence. This is true of any procedure which is not done in the manner in which it should be done. The results not being apparent to the layman he does not challenge the methods employed.

Received October 12, 1944.

Book Reviews

Rosenstein, J. L. *The Scientific selection of salesmen.* New York: McGraw-Hill, 1944. Pp. xii + 259. $3.00.

The audience for, and major objective of, this book is stated as follows by the author: "This book is for sales executives who are long-range minded. Its purpose is to describe, to explain, and to teach the steps in a scientific salesman selection program" (ix). For many reasons the publication fails by a wide margin to meet either the needs of its intended audience or its primary objectives.

Throughout the book there are evidences of hasty, superficial writing. Important concepts are ignored or treated so sketchily that they might better have been ignored. On the other hand, certain simple ideas, such as the computation of an average, are heavily labored. Part of the difficulty encountered by the author arises from his attempt to oversimplify psychological tools and techniques which just cannot be so treated for lay readers. An example of this is the attempt to teach interpretation of complex psychographs to laymen in fewer than forty pages (211–244). In the section on interviewing, such terms as "substitution," "persecution," and "projection" are introduced with little explanation for naive readers.

Treatment of tests and testing is entirely inadequate. Two quotations suffice to indicate the general approach to measurement.

"Do not be troubled about the matter of administering tests. The instructions for each test are simple and, if followed carefully, should present no difficulty" (169). . . ."*Tests for Basic Interests.* For an investigation into the kinds of activities in which an individual is interested, one of the best known tests is the Preference Record, by G. Frederic Kuder.

"Preferences will certainly be exhibited in the degree of enthusiasm with which an individual enters into various activities. It may be wise to learn the preferences displayed by your successful salesmen as compared with those who fail" (167–68). This last quotation is the complete information given the reader about a test which is recommended for a selection battery!

Sections of the book are devoted to the application blank, and selection of salesmen for small companies. Materials concerned with the application blank are the strongest point in the publication. Even in this section much of importance is ignored. Readers who wish to read further about

topics which interest them will be irritated by the author's failure to include sources. The names of writers and researchers are referred to, but the publications and publishers are omitted.

In the opinion of the reviewer, this is a poor book on a topic which is deserving of much better treatment.

Milton E. Hahn

Syracuse University

Traxler, Arthur E. *Techniques of guidance: Tests, records, and counseling in a guidance program.* New York: Harper & Brothers, 1945. Pp. xiv + 394. $3.50.

The first thirty or forty pages of this compact volume may give the reader, sophisticated or otherwise, some blank misgivings. But if he persists, his patience will be richly rewarded. Few books that have come to my attention in recent years have been more appropriately titled or more effective in their progression. From a conventional beginning that toys with definition, staff organization, and costs, the science of guidance gradually becomes the art of bringing into conjunction to their mutual advantage the potentialities of pupils and the resources of school and community.

School and community resources are treated rather generally but with ample reference to sources of information. Understandably the curriculum, which is the school's chief formalized resource, is neither described nor challenged; but the growth of the extracurriculum is given subtle but effective emphasis as a promising adjunct to readin', writin', and 'rith metic.

If facts are the beginning of wisdom, then facts about the pupil—as a learner, a personality, and a social being—are the *sine qua non* of guidance. Kinds of appropriate facts are outlined: home background, school history, mental ability, achievement and growth in fields of study, health, out-of-school experience, interests, special aptitudes, personality, and plans for the future. Use of the questionnaire and the interview is discussed and their values and limitations highlighted.

Tests as instruments of fact finding, however, are given the largest amount of space and the most exhaustive treatment. Aptitude as a concept is intelligently discussed, and likewise the fact of individual differences; but without any attempt at explaining the why. A selected but reasonably exhaustive list of tests carefully and fully annotated is attached, including titles, authors, publishers, research information and references.

An even more extensive array of achievement tests is described with equal fidelity to fact. These fall mainly within the areas of reading,

general achievement, English, foreign language, mathematics, science, and the social studies.

Appraisal of personality is treated under two headings: (1) tests, with a rather extensive annotated list included, and (2) anecdotal records and behavior descriptions accompanied with discussions of the values and pitfalls of both tests and records or descriptions.

Planning and administering a testing program and scoring, organizing, and reporting test results are fully and effectively treated with concrete suggestions drawn from actual practice buttressing the general discussion. A variety of services and possible cooperative ventures are pointed out for schools not fully equipped to engineer a program without outside help.

The possible *uses* of test results point up sharply the tremendous lag between test construction and test-giving on the one hand, and on the other, what is done about all this fury of activity. With infinite patience Dr. Traxler describes the instructional uses of tests. He elaborates them so fully and with such reasoned precision that he may feel, as many readers will, that he has argued his case perceptibly beyond the point of diminishing returns. Administrative uses of test results, and by inference, their possible effect upon the curriculum, are it appears "outside the scope" of his book.

Within the conventional setting of school resources, counseling uses of test results are recommended to identify individual weaknesses of pupils, to discover special abilities, and as a basis for conferences on behavior adjustments, course sequences, vocational and educational planning. But tests are only one element in the total guidance program.

"A comprehensive and detailed system of cumulative personnel records is indispensable for the proper functioning of the modern school." Some eighty pages of text and sample forms are devoted to the cumulative record and reporting devices and to dependence on facts of status and progress for immediate or ultimate attainment of desirable educational or career objectives. The ideal is admirable and convincingly presented as within the realm of the attainable. Comparability of test data is projected as essential. Adequate and systematically planned assembling and recording of other kinds of data are stressed as equally important. If both kinds of information are to be significantly useful, they must take their origin not from tests and records as such but from "a study of the nature and purposes of the school and of the pupil." Useful, practical suggestions are given for filing and accessibility of materials.

"The whole thesis of this book, however, is that counselors who are not psychologists are entirely capable of performing the *distributive functions* of guidance and many of the *less involved adjustive functions*, provided they will get acquainted with and use the techniques for knowing individuals." To this end lists of references, not exhaustive, but

well chosen, have been appended to each chapter; and the final chapter consists of reading resources for counselors. For those who have the urge to learn their students as well as teach them, Dr. Traxler's volume holds out great promise. For those who are professionals in the field of guidance, the volume is an excellent handbook.

F. S. Beers

Social Security Board,
Washington, D. C.

Scott, Dorothy D., Morgan, Winona L., and Lehman, Ruth T. *Developing a student guidance program in an instructional department.* The Bureau of Educational Research, Ohio State University. 1945. 65 pages.

The monograph describes the procedures used for the past several years in the School of Home Economics at Ohio State University in an attempt to provide more adequate student guidance and to determine techniques useful to the teacher counselor. The plan was inaugurated because it had been found that many students graduated without any faculty member really knowing them, and many made unsatisfactory vocational choices.

The staff accepted the idea that colleges should be concerned for the all-round development of the students, that the guidance point of view should permeate student-faculty relations, and that the college staff can best acquire this through participating in a guidance program.

Responsibility for guidance is divided among three groups. The two coordinators are chiefly concerned with administration although they do some counseling and teaching; the general advisers retain the same advisees throughout their four years in college, hold planned conferences with each of them (and additional conferences upon request) to analyze (the students') progress, plan next steps, and suggest resources for their personal development; and the professional advisers plan policies for selecting students, provide group guidance on professional problems and assist in placement. Most faculty members serve as general advisers and the heads of departments as professional advisers.

Individual Counseling. Each conference with the general adviser is planned with a specific purpose, although plans may be altered if desired. The chief idea is to help students and faculty to get acquainted and to put students in touch with sources of special help which may be needed, such as the Health Service, the Employment Service, and the Psychological Clinic. The first conference is held during Freshman Week, the second in the spring. The sophomore conference comes in the middle of the year and is planned to offer help in making a vocational choice. The last planned conference is arranged for the fall of the junior year and at

that time students are helped to analyze what has been accomplished during the first two years and what should be planned for in the last two in order to get the maximum cut of college. Students may initiate conferences during the senior year as they may during the preceding years, but no definite conference is scheduled. Informal entertaining of small groups in her office or at the adviser's home provides a very worth while type of contact.

Transfers are assigned to advisers when they enter and they furnish much of the same personnel information which the freshmen do.

Group Guidance. Several types of group guidance are offered. The Freshman Orientation course which is required of all entering freshmen, meets three times a week, and carries two credits. The course includes small group discussions for 30 or 40 students, counseling by instructors and selected older students, collection of personnel information, and administration of most of the tests used. Professional guidance is given through meetings sponsored by professional advisers—sometimes for those specializing in the department and sometimes open to all students. Discussion of pertinent material, student participation in the program, and recognition on the part of the students of the need for the information probably explain the high attendance at these meetings.

The Guidance Office is under the direction of the coordinators and handles much of the routine work of the program, such as providing advisers with all needed forms, keeping confidential folders up to date, and administering tests. The coordinators take charge of scheduling laboratories for underclass students and the professional advisers of those for upperclass students, and in these, students work out their schedules and can obtain individual assistance if it is needed.

Rating of students is done by staff members with a relatively simple form and provision is also made for recording any comments instructors wish to make about the student. Ratings are given on only those points for which the instructor believes she has a basis for judgment and students are allowed to see their ratings when an adviser is available to help them interpret them. Careful self-evaluation is provided for at several stages.

The appendix includes copies of all of the forms used in the guidance program, an outline of the orientation course, and an annotated list of the tests and inventories used.

Clara M. Brown

University of Minnesota

Klein, D. B. *Mental hygiene,* the psychology of personal adjustment. Henry Holt, 1944, xiii + 489.

Mental hygiene has reached the stage where specialists in the field should be factual, critical, and systematic. In the first major section of

the text, Dr. Klein fulfills excellently his preface promise to meet these criteria. Here, he discusses in some detail with documentation an objective and eclectic view of the psychoses and psychoneuroses and the prophylaxis pertinent to each of them. The author's second division of the field, called by him "Promotion of Mental Health," is presented in the form of loosely connected essays, mostly on important but selected topics. The home, conscience, motivation, coping with reality, repression, economic barriers, and education are the subjects of the chapters of this section. Despite the fact that there is a voluminous literature on parent-child relationships, only two references appear in the entire chapter on the home. The chapter on education deals with selected important problems but the reader may leave it without realizing the extensive factors in education affecting morale. The influences of the playground, athletics, cliques, and other extracurricular events, for example, are omitted.

The author warns that he will restrict himself "to the confines of mental hygiene territory." This apparently explains the omission of a concise preliminary review of basic psychological concepts as motivation, adjustment, conditioning, inhibition, symbolism, etc., and fundamentals in a theory of personality. It does not explain why psychoses and psychoneuroses are given a disproportionate emphasis at the expense of juvenile delinquency, child and adolescent personality and behavior problems and psychosomatic difficulties.

Dr. Klein's book makes certain distinct contributions to the field. The discussion of specific prophylaxis for each mental abnormality is an example. The forceful chapter devoted to the economic and social aspects of mental hygiene reminds us that there are factors of social control in mental health which are outside of the influence of individual psychologists or psychiatrists. The recent periodical literature is related to a discussion of basic theoretical problems, such as the distribution of mental illness, the extent to which it is constitutional or the result of conflict, the implication of the animal studies and the meliorative and prophylatic roles of the hygienist. These are a reminder that too much has been written in this field without first examining basic premises, as Dr. Klein did.

The task of meliorative mental hygiene as the author sees it is to develop a philosophy of life and high morale. This is not achieved, he stresses, through an array of mental hygiene maxims or drills. This emphasis is a good antidote for some kinds of pseudo mental hygiene. It is congruent with the prevalent non-directive trend in psychotherapy. However, discussion of specific problems and techniques as a means of eliciting insights and building attitudes in youth can be achieved by a skillful presentation without jeopardizing the reader's self direction or

independence of action. This reviewer believes Dr. Klein could have strengthened his book pedagogically by greater use of this specific approach. The underclassman, however, should find the text readable, stimulating to insights, and socially progressive.

Fred McKinney

University of Missouri

Bowley, Agatha H. *Guiding the normal child.* New York: Philosophical Library, 1943. Pp. xv + 174. $3.00.

This book which is addressed to parents, teachers, social workers, and physicians contains many practical suggestions for dealing with behavior and adjustment problems of children. Its author, who is a lecturer in the teachers' training college at Dundee, Scotland, has had wide experience with nursery schools and as a psychologist in the Dundee Child Guidance Clinic.

Beginning with an account of the child's development during infancy, the treatment carries forward to the end of the adolescent period. The specific chapter titles are Infancy, The Pre-School Period, Difficulties During the Pre-School Period, The Middle Years of Childhood, Difficulties During the Middle Years of Childhood, Adolescence—Development and Difficulties, and Children and the War.

The volume is exceptionally easy reading and contains numerous short case studies which adds to its interest. It is decidedly not a typical textbook on child psychology, and probably should not be used for this purpose. It would, however, provide excellent supplementary reading in connection with a course in child psychology. It is distinctly a "how" book.

For the most part the suggestions it gives for child guidance appear to be based upon a sound psychology of learning and adjustment. Occasionally, however, the author propounds a theory or takes a position which seems at variance with the best current thought in America. For example, in discussing fears of the pre-school child, she says: "These fears are largely the result of unconscious feelings of badness, and may be termed *anxieties*. . . . He may fear that his parents may desert or harm or starve him if he is unworthy and unlovable because he sometimes harbours bad, hateful feelings towards them. If he feels so to them they may reciprocate and retaliate. . . . This would seem to be at the root of the phobias of the pre-school child which are so very common. Fears of dogs, cats and spiders, for instance, frequently represent a projection of those unconscious fears on to some object in the external world against which he may enlist protection" (p. 63). In other words, the child may be afraid of dogs or cats not because of previous unpleasant experiences with them, but because he has an unconscious fear of his parents. With

respect to the development of intellectual traits, the author has a strong hereditarian bias. She says: "The dull child is dull by virtue of his poor mental inheritance. It is important to recognize his degree of dullness, to assess his mental age and so plan a curriculum that suits him and ensures that his needs are satisfied" (p. 92). In view of recent findings with regard to the constancy of the IQ, this seems to be a rather strong statement. Her definition of adolescence as being "that period between 13 and 18 years for boys, and 12 and 16 years for girls" (p. 131) would not generally be accepted as valid in this country. Our boys and girls seldom achieve social maturity or become weaned from their families at such early ages.

Despite these minor criticisms, the book has very much to commend it. It is functional, and highly suggestive with respect to child guidance procedures. The chapter on Children and the War is particularly timely and valuable. Dr. Bowley's book can be read with profit by anyone who desires a straightforward, simple, and dynamic explanation of child behavior problems and methods of dealing with them.

Glenn Myers Blair

University of Illinois

New Books, Monographs, and Pamphlets

Books, monographs, and pamphlets for listing and possible review should be sent to Donald G. Paterson, Editor, Department of Psychology, University of Minnesota, Minneapolis 14, Minnesota

Studies of teachers' classroom personalities, I. Dominative and socially integrative behavior of kindergarten teachers. Harold H. Anderson and Helen M. Brewer. Stanford University: Stanford University Press, 1945. Pp. 157. $2.00. Applied Psychology Monograph No. 6.

The enrichment of life. Paul N. Elbin. New York 17: Association Press, 1945. Pp. 87. $1.50.

Selection of students for vocational training. Fred M. Fowler. Washington: Government Printing Office, 1945. Pp. 156. U. S. Office of Education, Vocational Division Bulletin No. 232.

Through a dean's open door. A guide for students, parents, and counselors. Herbert E. Hawkes and Ann L. Rose Hawkes. New York: McGraw-Hill Book Co., Inc., 1945. Pp. 247. $2.50.

Principles of guidance. Arthur J. Jones. New York 18: McGraw-Hill Book Co., Inc., 1945 (Third Edition). Pp. 582. $3.50.

Price control and business. George Katona. Bloomington: The Principia Press, Inc., 1945. Pp. 246. $3.00. Cowles Commission Monograph No. 9.

Diagnostic psychological testing. David Rapaport. Chicago 4: The Year Book Publishers, 1945. Volumes I and II $6.50 each, postpaid; set $12.00, postpaid.

The dice of destiny. An introduction to human heredity and racial variation. David C. Rife. Columbus, Ohio: Long's College Book Store, 1945. Pp. 163. $1.75.

Human nature in the making. Max Schoen. New York 3: D. Van Nostrand Co., Inc., 1945. $2.50.

Pioneers of tomorrow, A call to American youth. Hans Weil. New York 17: Association Press, 1945. Pp. 81. $1.25.

Frontier thinking in guidance: An anthology of significant thought in the field of guidance. Edited by John R. Yale. Chicago 4: Science Research Associates, 1945. Pp. 160. $2.00.

Practical handbook for counselors. Developed by New York State Counselors Association. Chicago: Science Research Associates, 1945. Pp. 160. $1.50.

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ABOUT THE AUTHOR

Dr. Max Schoen is head of the Department of Psychology and Education of the Carnegie Institute of Technology; Member of the American Psychological Association; member of the American Association for the Advancement of Science, and the author of several books.

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